PRINCIPLES OF WOODWORKING

HERMAN HJORTH

Ferrin H. Sonderegger
345 North 2nd East
Logan, Utah

weaver

Wendell Petersen
850 N. 7 E.
Logan, Utah

Vendell & Iversen
Fall Quarter 1940

$8
175

Winter quarter - 1940
Allen Bond
850 N 7 East
Logan.

$1.25
take to professor
Swenson Woodwork

Don Day when I'm awful low & the world is old I

Ch. 19 P. 223.

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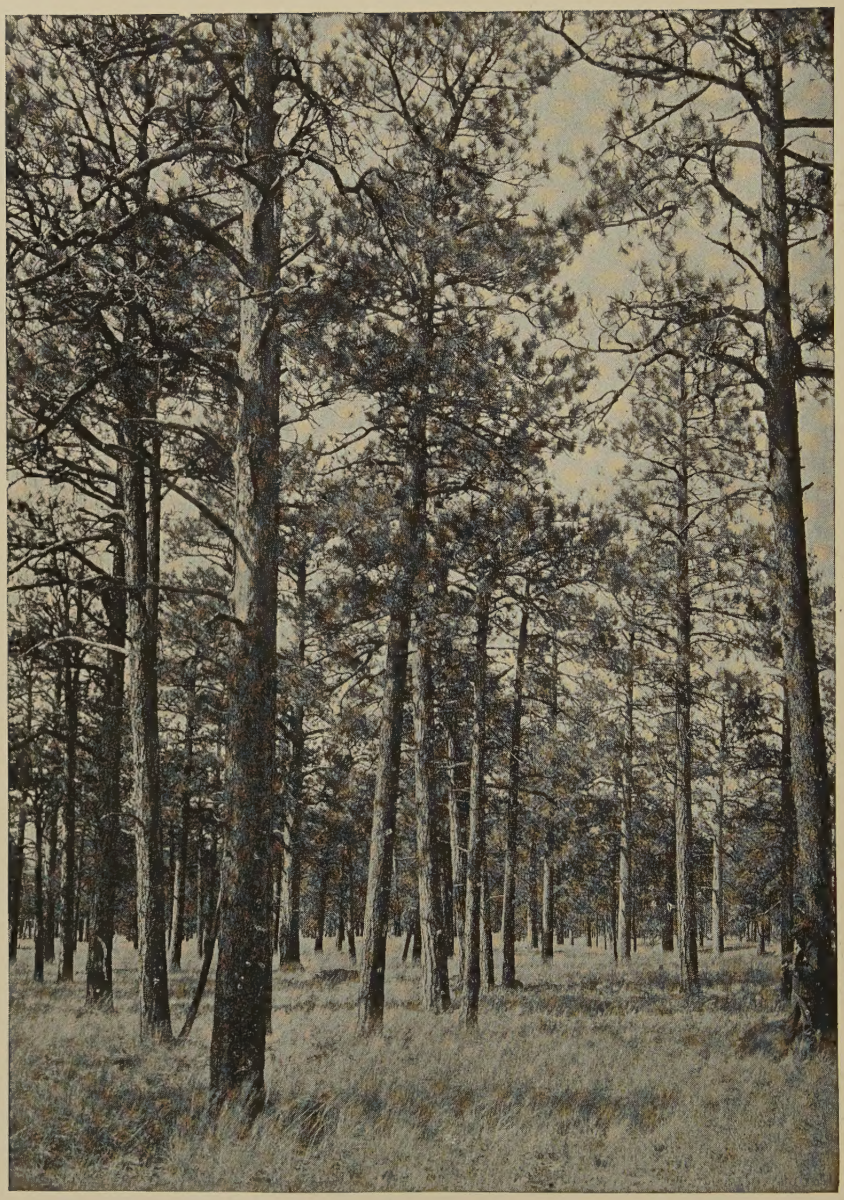
Principles of Woodworking



Enormous quantities of lumber have been wasted through neglect and carelessness, but much is being done to eliminate waste and conserve the supply of lumber. (See p. 224.)

A good stand of western yellow pine, Coconino National Forest, Arizona. (Photo by A. Gaskill. Courtesy U. S. Forest Service.)

Principles of Woodworking

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PREFACE

During all ages wood has played an important and friendly part in the development of mankind. It enters, directly or indirectly, into the construction of more manufactured articles than any other material, and there is not an engineering project nor construction of any kind, in which wood is not used in some way.

A material, which enters so extensively into every phase of life, is of tremendous economic value to all civilized nations. The woodworking industries in this country, particularly the building and furniture industries, are among the most important, because they employ thousands of highly skilled workmen, designers, and artists, to produce useful as well as beautiful articles of wood. Other thousands are engaged in the distribution and selling of these products, and still other thousands in the manufacture of the numerous tools and machines used in woodworking.

This text is intended not only for the use of students in secondary and vocational schools, but also for adults who have taken up the study and practice of woodworking as a hobby.

Fundamental tool processes, common to all woodworking trades, have been compiled and arranged in family groups. With these as a basis, cabinetmaking has been emphasized throughout the book, because of its universal interest and appeal, and because this phase of woodworking is probably elected by most students.

All tool operations have been described and written in the form of instruction sheets. These have been further supplemented with related information about materials, tools, and machinery, and by a series of furniture projects, the construction of which has been carefully analyzed and described.

The teacher of woodworking will find the subject matter — both instruction sheets and related information — in convenient form for assignments.

Special attention is called to the method of planning and analyzing the various tool operations involved in the construction of an object. By following this method, any cabinet job may be analyzed and reference made by number to topics describing the various tool operations. After the students have become acquainted with the book, they should do their own thinking and planning, and should formulate their own job sheets for approval by the teacher.

The review questions at the end of each chapter should be of value to the student in testing his knowledge of a given topic, and to the teacher in checking up on his class.

The teacher of general science will find much helpful material on

forest conservation, seasoning of lumber, and the physiological processes of the tree.

The teacher of physics will find the chapter on machinery helpful in illustrating the principles and practical applications of simple machines and the transmission of power.

It is the sincere hope of the author that the increasing number of "home woodworkers" will find this book helpful and stimulating, and that it will contribute to their interest and pleasure in craftsmanship. May they experience that satisfaction and joy of achievement which comes with a piece of work well done.

Grateful acknowledgment is hereby given to the following: Miss S. E. Sievers of Saunders Trades School for valuable help in reading and preparing the manuscript; Mr. J. Macdonald and Mr. H. A. Carlberg of Saunders Trades School for suggestions and criticisms; Mr. Arthur Wakeling, Home Workshop Editor of Popular Science Monthly, for permission to use the material on Wood Turning and Inlaying which was published in a series of articles in that magazine, together with some of the illustrations in topics 255, 325, 326, 327, 328, 330, 334, and 341, which were used in these articles; the Forest Products Laboratory, Madison, Wis., and the National Lumber Manufacturers' Association for most of the illustrations appearing in the chapter on Wood; the Oliver Machinery Company for the illustrations in Figures 97 and 118; and the Editor of the Industrial-Arts Magazine for permission to use material published in that periodical.

Yonkers, N. Y.
January, 1930

HERMAN HJORTH

TABLE OF CONTENTS

Chapter *Page*

PREFACE v

I. HAND TOOLS 1

1. Bench. Measuring Tools. 2. Rule. 3. Measuring Tapes. 4. Try-Squares. 5. Miter and Try-Squares. 6. Sliding T Bevels. 7. Steel Square. 8. Brace Measure. 9. Octagon Measure. 10. Board Measure. 11. Rafter Table. 12. Marking Gauge. 13. Panel Gauge. 14. Slitting Gauge. 15. Mortising Gauge. 16. Butt Gauge. 17. Dividers or Compasses. 18. Trammel Points. 19. Inside and Outside Calipers. 20. Plumb and Level. 21. Plumb Bob. Saws. 23. Ripsaw. 24. Crosscut Saw. 25. Backsaw. 26. Dovetail Saw. 27. Compass Saw. 28. Keyhole Saw. 29. Turning Saw. 30. Hack Saw. 31. Coping Saw. 32. Miter Box. Planes. 34. Jack Plane. 35. Fore Plane. 36. Jointer. 37. Smooth Plane. 38. Circular Plane. 39. Block Plane. 40. Bullnose Plane. 41. Rabbet-and-Fillister Plane. 42. Dado Plane. 43. Match Plane. 44. Router Plane. 45. Universal Plane. 46. Molding Planes. 47. Plane Gauges. 48. Spokeshave. 49. Scrapers. Chisels. 51. Firmer Chisel. 52. Paring Chisel. 53. Framing Chisel. 54. Butt Chisel. 55. Mortise Chisel. 56. Gouges. 57. Carving Tools. 58. Drawknife. Boring Tools. 59. Auger Bits. 60. Dowel Bits. 61. Car Bits and Ship Augers. 62. Expansion Bits. 63. Gimlet Bits. 64. Twist Bits. 65. Forstner Bits. 66. Bradawl. 67. Countersink. 68. Plug and Washer Cutters. 69. Plain Brace. 70. Ratchet Brace. 71. Bit-Brace Extension. 72. Auger-Bit Gauges. 73. Automatic, Reciprocating, and Hand Drills. Miscellaneous Tools. 75. Plain Screw Drivers. 76. Automatic Screw Drivers. 77. Screw-Driver Bits. 78. Claw Hammer. 79. Nail Sets. 80. Mallets. 81. Hatchets. 82. Rasps and Files. 83. Steel Bar Clamps. 84. C Clamps. 85. Column Clamps. 86. Hand Screws. 87. Monkey Wrench. Review Questions.

II. MACHINE TOOLS 27

89. Swing Cut-Off Saws. 90. Use of Swing Cut-Off Saw. 91. Under-Swing Cut-Off Saw. 92. Circular Saw. 93. Directions for Using Circular Saw. 94. Band Saw. 95. Jig Saw. 96. Jointer or Hand Planer. 97. Directions for Adjusting Tables. 98. Planer or Surfacer. 99. Mortising Machines. 100. Shaper. 101. Portable Shapers and Routers. 102. Wood Trimmer. 103. Belt Sander. 104. Disk Sanders. 105. Spindle Sander. 106. Drum Sanders. 107. Portable Sanders. 108. Sharpening Machines. 109. Automatic Knife Grinders. Review Questions.

III. THE SHARPENING OF TOOLS 54

Sharpening Ripsaws and Crosscut Saws. 111. Jointing Saws. 112. Setting Saws. 113. Filing Ripsaws. 114. Filing Crosscut Saws. 115. Sharpening a Plane Iron. 116. Sharpening Gouges. 117. Sharpening and Adjusting a Veneer Scraper. 118. Sharpening a Cabinet Scraper. 119. Sharpening an Auger Bit. Sharpening Turning Tools. 120. Gouge.

Chapter *Page*

121. Square-Nose Chisel. 122. Skew Chisel. 123. Parting or Cut-Off Tool. 124. Round-Nose Chisel. 125. Diamond-Point or Spear-Point Chisel. 126. Right or Left Skew Chisel. 127. Cleaning a Rasp or File. Sharpening Circular Saws. 128. Jointing Circular Saws. 129. Filing Circular Saws. 130. Gumming Circular Saws. 131. Setting Circular Saws. 132. Side Filing Circular Saws. 133. Brazing Band Saws. Sharpening Band Saws. 134. Setting Band Saws. 135. Filing Band Saws. 136. Sharpening Planer or Trimmer Knives. Review Questions.

IV. PLANING AND SQUARING TO DIMENSIONS 70

138. Squaring Boards to Dimensions. 139. Jointing Boards for Gluing. 140. Squaring a Table Top. 141. Making and Squaring Table Top with Machine Tools. 142. Squaring Table and Cabinet Legs. 143. Tapering Square Legs for Tables and Cabinets. 144. Tapering Square Legs on the Circular Saw. Review Questions.

V. GROOVED JOINTS 79

146. Making a Rabbet Joint. 147. Making a Dado Joint. 148. Making a Gain Joint. 149. Making a Grooved Joint. 150. Making a Groove and Rabbet Joint. 151. Making a Dado and Rabbet Joint. To Make Grooved Joints with Machine Tools. 152. Cutting Grooves, Dadoes, and Rabbets with a Dado Head. 153. Cutting Grooves, Dadoes, and Rabbets with a Circular Saw. 154. Cutting Tongues. Grooves, and Rabbets on a Shaper. Review Questions.

VI. DOWEL JOINTS 85

156. Making a Doweled Joint. 157. Joining Legs to a Turned Column with Dowels. Review Questions.

VII. LAP OR HALVING JOINTS 90

159. Making an End-Lap Joint. 160. Making an End-Lap Joint with Rabbet. 161. Making a Cross-Lap Joint. 162. Making a Dovetail-Lap Joint. Review Questions.

VIII. MORTISE-AND-TENON JOINTS 94

164. Making a Blind Mortise-and-Tenon Joint. 165. Making a Haunched Mortise-and-Tenon Joint. 166. Making a Through Mortise-and-Tenon Joint. 167. Making a Slip Joint. 168. Making a Mortise on a Mortising Machine. 169. Cutting Tenons on the Circular Saw. Review Questions.

IX. DOVETAIL JOINTS 103

171. Making a Through, Multiple, Dovetail Joint. 172. Making a Half-Lap, Multiple, Dovetail Joint. Review Questions.

X. MISCELLANEOUS CONSTRUCTIONS 107

174. Making a Drawer. 175. Making Drawer Rails and Guides. 176. Making a Panel Structure. 177. Making a Miter Joint. 178. Nailed Miter. 179. Doweled Miter. 180. Slip-Feather Miter. 181. Spline Miter. 182. Making a Rule Joint. 183. Making a Finger

Chapter *Page*

Joint. 184. Making Slide Supports. 185. Making a Checkerboard. Review Questions.

XI. GLUING AND CLAMPING 119

187. Preparing Glue. 188. Gluing Directions. 189. Gluing Boards Edge to Edge. 190. Gluing Frame or Panel. 191. Gluing Bookshelves. 192. Gluing a Cabinet. 193. Gluing a Drawer. 194. Gluing a Chair. 195. Gluing Miters or Irregular Shapes. 196. Gluing Doweled Joints and Segments. Review Questions.

XII. APPLICATION OF HARDWARE 130

198. Applying Screws. 199. Fastening Table Top. 200. Fastening Hinges. 201. Attaching Locks. Fastening Catches and Bolts. 202. Elbow Catches. 203. Door Bolts. 204. Flush Bolt. 205. Ball Catches. 206. Table Catch. Attaching Casters, Glides, and Chair Tips. 207. Casters. 208. Glides. 209. Chair Tips. 210. Furniture Pulls and Knobs. Review Questions.

XIII. WOOD TURNING 140

212. History. 213. Lathe and Parts. 214. Bed. 215. Headstock. 216. Countershaft. 217. Tailstock. 218. Toolrest. 219. Chucks and Faceplates. 220. Lathe Speed. 221. Centering and Clamping Stock in Lathe. 222. Turning Plain Cylinder. 223. Making Shoulder Cuts. 224. Making Taper Cuts. 225. Making Concave Cuts. 226. Making Convex Cuts. 227. Sanding in Lathe on a Spindle. 228. Turning a Disk. 229. Sanding in Lathe on a Disk. 230. Chuck Turning. 231. Split Turning. Review Questions.

XIV. SURFACE DECORATION 166

233. General Suggestions. Inlaying. 234. Inlaying Lines or Bands. 235. Inlaying Insets. 236. Cutting Straight Reeds. 237. Cutting Spiral Reeds. 238. Carving a Single Spiral on a Turned Cylinder. 239. Carving a Double Spiral on a Turned Cylinder. 240. Laying Out Tapered Spirals. Simple Carving. Tools. 241. Carving Beads. 242. Carving Chamfers and Hollows. 243. Carving Borders. Moldings. 244. Making Moldings. 245. Mitering and Applying Moldings. 246. Coping Moldings. 247. Shaping Table-Top Edges. 248. Matching and Applying Veneers. 249. Gluing Veneers. 250. Overlays, Frets, or Veining. 251. Decalcomania Transfers. Review Questions.

XV. UPHOLSTERY 196

253. History. 254. Plain Pad Seat. 255. Pad Seat with a Roll Edge. 256. Upholstering a Slip Seat. 257. Weaving a Fiber Seat. 258. Weaving a Cane Seat. 259. Applying Cane Webbing. Review Questions.

XVI. WOOD FINISHING 212

261. Preparing the Surface. Stains. 262. Water Stains. 263. Spirit Stains. 264. Oil Stains. 265. Acid Stains. 266. Staining Directions. 267. Wood Filler. Finishing Coats. 268. Shellac. 269. Lacquer. 270. Varnish. 271. Wax. 272. Linseed Oil. 273. Summary of Advantages

Chapter *Page*

and Disadvantages of the Finishing Coats. To Paint Furniture and Interior Woodwork. 274. Preparing the Surface. 275. Applying Priming Coat. 276. Filling Holes and Imperfections. 277. Applying Undercoats. 278. Finishing Coats. Review Questions.

XVII. WOOD 223

280. Botanical Division of Trees. 281. Life Function of Trees. 282. Man's Dependence on Plants. 283. Conservation of Lumber. Structure of Wood. 284. Cell Formation. 285. Annual Rings. 286. Heartwood and Sapwood. 287. Cambium. 288. Bark. 289. Medullary Rays. 290. Porous Woods. 291. Weight of Wood. 292. Reproduction of Trees. 293. Logging Operations. 294. Sawing Logs. 295. Plain- and Quarter-Sawing. 296. Seasoning Wood. 297. Air Seasoning. 298. Kiln Seasoning. 299. Moisture Content. 300. Types of Kilns. 301. Wood Shrinkage. 302. Drying Defects. Manufactured Lumber. 303. Standard Lengths and Thicknesses of Lumber. 304. Allowance for Planing. 305. Board Measure. Types of Manufactured Lumber. 306. Matched, Grooved, and Beaded Boards. 307. Moldings. 308. Veneers. 309. Plywood. 310. Uses of Plywood. 311. Manufactured Boards. Selection and Uses of Lumber. 312. Lumber for Cabinetwork and Interior Woodwork. 313. Lumber for Building. 314. Principal Cabinet Woods. 315. Principal Woods Used in Building. Review Questions.

XVIII. APPLIED PROJECTS 250

317. Preliminary Steps in Construction. 318. Making Drawings and Blue Prints. 319. Reading Working Drawings. 320. Reading Drawing of Bookrack. 321. Bookrack. Suggested Order of Tool Operations. 322. Reading Drawing of Footstool. 323. Footstool. Tool Operations. 324. Reading Drawing of Early English Gate-Leg Table. 325. Early English Gate-Leg Table. Tool Operations. 326. Serving Tray. Tool Operations. 327. Mirror Frame. Tool Operations. 328. Stand. Tool Operations. 329. Lamp Standard. Tool Operations. 330. End Table. Tool Operations. 331. Stool. Tool Operations. 332. Occasional Table. Tool Operations. 333. Umbrella Stand. Tool Operations. 334. Cabinet. Tool Operations. 335. Bedside Table. Tool Operations. 336. Base and Column. 337. Bedside Table Top. 338. Chess Table Top. 339. Sewing-Table Top. 340. Dining Chair. Tool Operations. 341. Chest. Tool Operations.

INDEX 303

Principles of Woodworking

CHAPTER I

HAND TOOLS

The woodworker uses a large variety of hand tools. Every workman should be familiar with the tools which he uses. He should know their proper names, the purpose for which each is used, and how they are sharpened and kept in good condition.

In this chapter a brief description is given of the most commonly used hand tools. In a later chapter the sharpening of tools is explained in detail.

1. **The bench** is a tool or appliance of the utmost importance to the woodworker. The best type of bench has a top that is constructed of narrow strips of hard wood, glued and bolted together. It usually has

Fig. 1. Workbench

a recess or trough in which tools may be placed while working. The top is bolted to a frame consisting of four legs braced securely with cross-pieces. This frame is often fitted with one or more drawers. (Fig. 1.)

The bench top is equipped with a side vise and sometimes also with a tail vise. These vises are made either of wood or iron. They have a central screw and parallel guide bars, one on each side of the screw. (Fig. 2.) Some iron vises are of the "continuous-screw" type and others of the "quick-acting" type. On some quick-acting vises a section of the screw thread is cut away throughout the entire length of the screw. This permits the movable vise jaw to be pulled in or out when the screw is in a certain position. A partial turn to the right tightens these quick-acting vises.

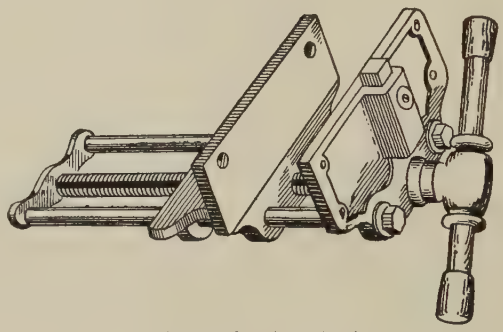


Fig. 2. Quick-acting vise

Some vises are equipped with an adjustable dog; i.e., a piece of iron which moves in a slot in the vise jaw. It can be set flush with the top of the vise jaw, or raised above it. A corresponding bench stop fits into holes bored in the bench top so that a piece of wood may be clamped firmly between the bench stop and the vise jaw.

A tail vise is a great convenience on a workbench, because it permits of clamping long pieces, such as table legs, for planing or mortising.

MEASURING TOOLS

2. **A rule** is generally the first tool used by the woodworker. Rules are made in different lengths and of different materials. Those used by the woodworker are usually of the folding type, and measure from 2 to 8 ft. in length. (Fig. 3.) Rules are generally marked off on both sides in inches and subdivisions of an inch, but they are also made with inch divisions on one side and metric divisions on the other.

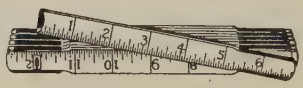


Fig. 3. Folding rule

3. **Measuring tapes** are used by carpenters, contractors, and architects. They are made of steel or cloth, and usually measure from 25 to 100 ft. in length. (Fig. 4.) They are divided into inches and feet, or meters and centimeters.

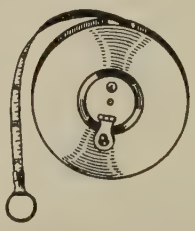


Fig. 4. Steel tape

4. **Try-squares** are used for testing the squareness of lumber, and in checking the squareness of work being assembled, especially in places where the framing square would be too large. Try-squares consist of two parts, the stock and the blade, which are firmly fastened together at right angles. The stock

is thick and is made of wood or iron. The blade, which is thin, is made of steel and has an inch scale stamped on it. (Fig. 5.) Try-squares are made in sizes of from 4 to 12 in., measured from the end of the blade to the stock.

5. **Miter and try-squares** (Fig. 6.) can be used at both 90 and 45 deg. Miter squares can only be used for angles of 45 deg.

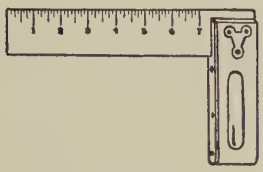


Fig. 5. Try-square

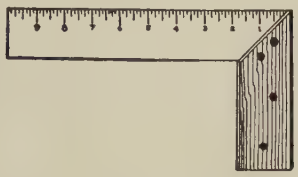


Fig. 6. Miter and try-square

Fig. 7. Sliding T bevel

6. **Sliding T bevels** (Fig. 7) are similar to try-squares, but differ in that their blades are adjustable to any angle. They are used for laying out angles other than right angles, as for instance corner braces, dovetails, or side rails for chairs.

7. **The steel square** measures 16 by 24 in., or 18 by 24 in., and is of the same thickness, about ⅛ in., throughout. The 24-in. part is called the "blade" or "body," and is 2 in. wide. The 16- or 18-in. part is called the "tongue," and is 1½ in. wide. The "face" of the square is the side on which the manufacturer's name is stamped. The steel square is a very important tool, especially to the carpenter, who uses it in laying out the many different cuts employed in roof framing, stair building, oblique joints, etc. The cabinetmaker uses it mostly for testing the flatness of large surfaces (Art. 189) and for testing for squareness in gluing. The uses of the steel square are so numerous and varied that whole books have been written on this subject.

Besides the divisions of the inch into eighths, tenths, twelfths, sixteenths, and thirty-seconds, which are marked on the inside and outside

Fig. 8. Brace measure

edges on both sides of the square, the following tables are marked on it: brace measure, octagon measure, board measure, rafter table, and the divisions of 1 in. into 100 parts.

8. **The brace measure** and octagon table are marked on opposite sides of the tongue. The brace measure consists of a series of three numbers. Two of the numbers are placed one above the other, and a third to the right of these as $\frac{48}{48}$ 67^{88}. (Fig. 8.) This means that a square having a side 48 in. or 48 ft. long, has a diagonal 67.88 in. or ft. long, as the case may be.

9. **The octagon measure** (Fig. 9) consists of a number of divisions marked along the center of the tongue. If an octagon is to be made

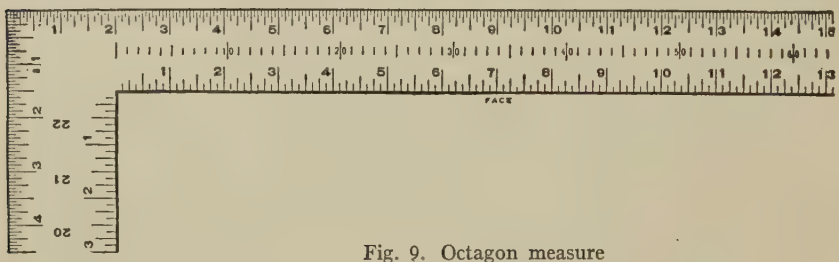


Fig. 9. Octagon measure

from a square board having a side of 10 in., the octagonal shape is laid out as follows: Locate the center points on each of the four sides of the square. Set a pair of dividers equal to 10 of the spaces on the steel square, and lay off this distance on each side of the center divisions. Connect all these points across the corners of the square board, and the octagon has been completed.

The following is a simple way to lay out an octagon from a square:

1. Draw the diagonals of the square.
2. With half the diagonal as a radius, and a corner of the square as a center, draw an arc from one side of the square to the other. Repeat the process from the remaining corners.
3. Connect the end points of the arcs across the corners of the square to complete the octagon. (Fig. 10.)

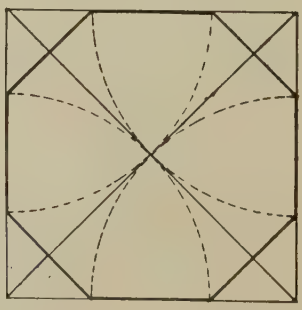


Fig. 10. To lay out an octagon from a square

10. **The board measure** is marked on the blade of the square, and enables one to read off the number of board feet a board or timber contains without making any calculations. (Fig. 11.) Under the 12-in. mark, on the outer edge of the steel square, is a column of figures, which refers to the length of the boards to be calculated. The other numbers on the inch scale, to right and left of the 12-in. mark, refer to the width of the boards.

To use the scale, read off the length of the board to be calculated, fol-

low this line to the number indicating its width, and the result is found in the column of figures under that number. For example, a board is 7 in. wide and 10 ft. long. Find 10 under 12 on the third line; follow to the left and stop under 7. The result, 5 ft. 10 in., is found on the third line under 7. For boards larger than 15 ft., divide the length into

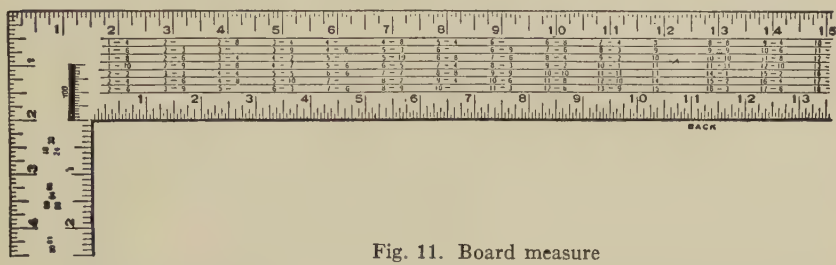


Fig. 11. Board measure

two smaller parts, find the board feet for each of these, and add the results. For example, to find the number of board feet in a board 10 in. wide and 17 ft. long, divide the length into 8 and 9, and follow these lines to the left until 10 is reached. An 8-ft. board contains 6 ft. 8 in. and a 9-ft. board 7 ft. 6 in. Adding these figures gives a total of 14 ft. 2 in. The scale is based on 1-in. boards. For 2-in. planks, multiply the results obtained by 2.

A board 12 ft. long contains as many board feet as it is inches wide. Similarly, a 6-ft. board contains half as many board feet as it is inches wide. For this reason the numbers 6 and 12 have been omitted from the column under the 12-in. mark.

11. **The rafter table** is not found on all squares, but when it is given it is stamped on the blade. (Fig. 12.) It can be used only for roofs having standard pitches.

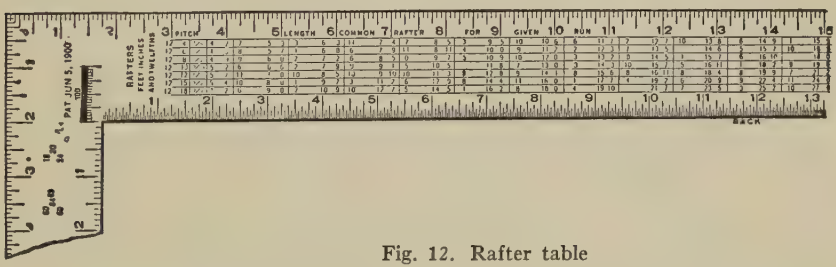


Fig. 12. Rafter table

Before explaining the rafter table, the terms "run," "rise," and "pitch" of a rafter must be understood. By the "run" is understood half the width of the building; by the "rise," the vertical height of the rafter over the top of the walls; and by the "pitch," the ratio between the rise and twice the run, or the total width of the building. (Fig. 13.)

A run of 12 ft. and a rise of 6 ft., therefore, give a pitch of $\frac{6}{24} = \frac{1}{4}$. A run of 18 ft. and a rise of 6 ft. give a pitch of $\frac{6}{36} = \frac{1}{6}$, and so on.

To use the table, determine the pitch of the roof, and read off the length of the rafter under the number on the inch scale corresponding

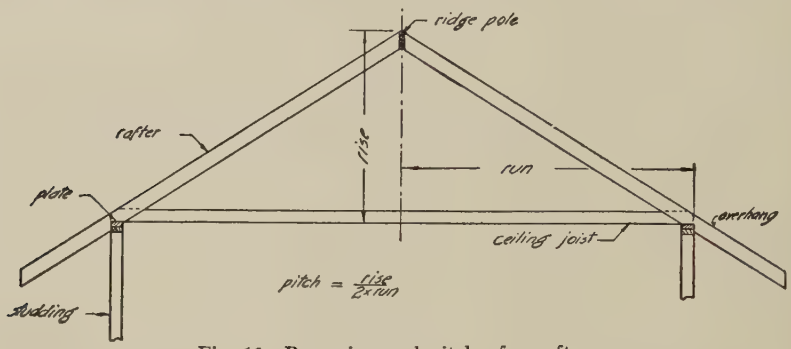


Fig. 13. Run, rise, and pitch of a rafter

to the length of the run. For example, a roof having a run of 12 ft. and a rise of 8 ft. has a pitch of $\frac{1}{3}$. The length of the common rafter found under 12 on the third line is 14 ft. $5\frac{1}{2}$ in.

Some manufacturers of steel squares use a different form of rafter table, which shows the length of both common, hip, valley, and jack rafters. The length, however, is given per foot run only, which means that the number found on the steel square must be multiplied by the length of the run in order to obtain the total length of the rafter.

If the pitch is irregular, as 15-ft. run and 10-ft. 6-in. rise, the length of the rafter may be found by measuring across the square from $10\frac{1}{2}$ on the tongue to 15 on the blade. If this measurement is made with another square, using the twelfth scale and counting each inch as a foot and each twelfth of an inch as a full inch, the length is immediately obtained in feet and inches. This method is also very convenient for measuring the length of braces.

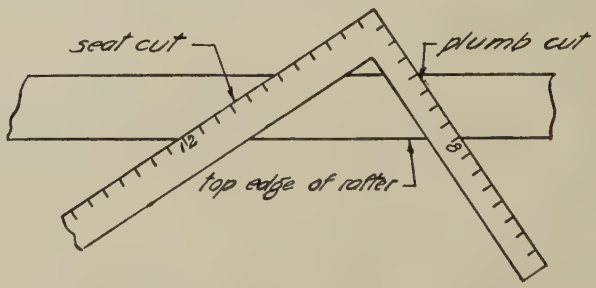


Fig. 14. Method of obtaining angles for cutting a rafter or brace

By placing the square on the side of the rafter or brace with the numbers indicating rise and run in line with one edge, the proper angles for cutting are obtained. (Fig. 14.)

12. **A marking gauge** is made of wood or steel. The one most commonly used consists of a square, wooden bar or beam, about 8 in. long, on which a wooden block or head slides. (Fig. 15.) This block can be fastened at any point of the bar by means of a brass setscrew bearing against a brass shoe. The block, on the best grade of gauge, is protected from wear by a piece of brass set flush with its surface. The bar is graduated in inches and provided with a steel point or spur fastened near the end with a screw. The spur must be filed to a fine point.

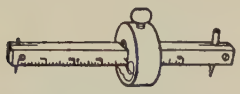


Fig. 15. Marking gauge

This tool is used for marking or gauging widths on narrow pieces of wood, such as table legs, etc. When using it, move the gauge away from you, and tip it slightly forward, keeping the block in contact with the edge or face of the board at all times.

As the spur may be easily bent out of place, most workmen disregard the graduations on the beam and measure the distance to be gauged from the spur to the face of the block with an ordinary rule.

An attachment for curves consists of a bent piece of brass fastened to the block of the gauge.

13. **A panel gauge** is similar to a marking gauge, but has a longer block and a beam 17½ in. long. (Fig. 16.) It is used for gauging the width of larger pieces, such as panels.

Fig. 16. Panel gauge

14. **A slitting gauge** is similar to a panel gauge, but has a handle in addition to the block. (Fig. 17.) It has a knife instead of a spur and is used for cutting thin stock.

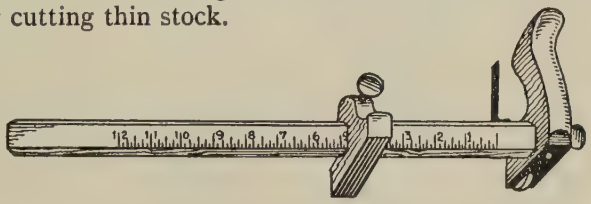


Fig. 17. Slitting gauge

15. **A mortising gauge** is a marking gauge with two spurs, which can be spaced at different distances and mark two parallel lines at the same time. One type is made of rosewood and has an adjusting screw in the end of the beam (Fig. 18), which moves one of the points up or down as desired. The other side of the beam is fitted with a single point as on the ordinary marking gauge. This gauge is used chiefly for

laying out mortises and tenons. Other types are made entirely of metal and have two bars.

16. **A butt gauge** differs from a mortising gauge in that its spurs are at the extreme ends of the beams. It can, therefore, be used in in-

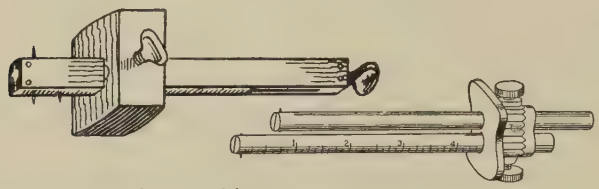


Fig. 18. Wooden mortising gauge

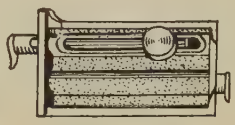


Fig. 19. Butt gauge

Fig. 18*a*. Metal mortising gauge

ternal corners such as on a door jamb when gauging for the width of hinges. It is made of steel and has three spurs. (Fig. 19.)

17. **Dividers or compasses** consist of two slender steel bars or legs sharpened to a fine point and held together at one end either by a movable joint or a spring. (Fig. 20.) They are made in lengths from 6 to 10 in., and are used to scribe small circles. A pencil holder may be attached to one of the legs.

18. **Trammel points** consist of two steel points which can be fastened to a wooden stick or bar at any distance from each other. (Fig. 21.) They are used to scribe larger circles such as are needed for circular table tops. A pencil point can be fastened to one of the points. A

Fig. 20. Dividers

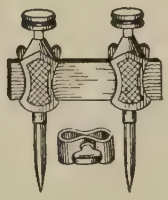


Fig. 21. Trammel points

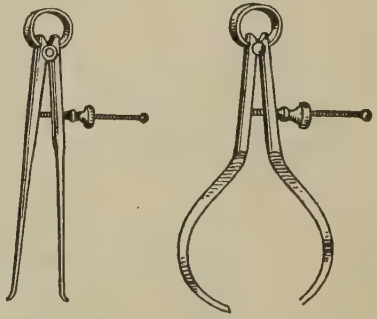


Fig. 22. Inside and outside calipers

finer tool for the same purpose, with bars made of steel, is used by draftsmen and is called a "beam compass."

19. **Inside and outside calipers** are similar in shape to dividers, but their legs are bent either inward or outward. (Fig. 22.) They are used chiefly in wood turning for measuring the inside or outside diameters of turned pieces.

20. **The plumb and level** is used principally by the carpenter. It consists of a piece of wood, often brass bound, about 1⅜ by 3 by 26 in.,

Fig. 23. Plumb and level

into which a spirit-level glass is fastened horizontally. (Fig. 23.) As the glass is not quite filled, a bubble always remains. When this bubble is in the center of the glass, indicated by lines marked on it, the structure on which the level rests is absolutely horizontal or level.

Most levels also have one or two glasses set vertically to the length of the level. These are called "plumb glasses," and serve to determine if a wall or timber is placed plumb or perpendicular to the horizontal. Levels are also made with an iron body. They vary greatly in length.

Fig. 24. Plumb bob

21. **A plumb bob** is a piece of metal shaped like a boy's top. (Fig. 24.) A cord is attached to the thick end of the bob. It is used in building construction, to test the perpendicularity or plumbness of any structure or part thereof. Plumb bobs are also used on leveling instruments to enable the surveyor to place the instrument accurately above any point.

SAWS

After measuring and laying out the portion of a board or plank wanted, the next step is to saw along the lines marked. Different types of saws are used for different sawing jobs. Some of the most common are as follows:

23. **The ripsaw** is used for ripping or cutting with the grain along a straight line. Blades of ripsaws vary in length from 20 to 28 in. They

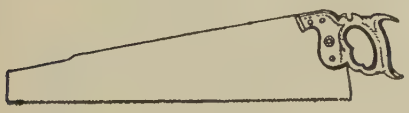


Fig. 25. Ripsaw

Fig. 27. Teeth of a ripsaw

are always wider at the handle than at the end, in order to prevent them from bending or buckling when they are pushed through the wood. (Fig. 25.) The teeth of a ripsaw vary in size according to the fineness of the work to be done. Their size is indicated by the number

of "points" to the inch; i.e., the number of teeth occurring in 1 in. less one. (Fig. 26.) For example, a 7-point saw has 7 tooth points, but only 6 complete teeth in 1 in. The number of points a saw contains is stamped on the blade near the handle of the saw. The teeth of a ripsaw are shaped like chisel points, and their forward edges are at right angles to the length of the blade. (Fig. 27.)

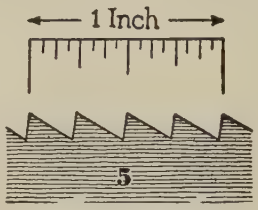


Fig. 26. Five points to the inch. Four complete teeth

24. **The crosscut saw** is similar in shape and appearance to the ripsaw. The only difference lies in the shape of the teeth, which are filed to a point instead of square across as on a ripsaw. (Fig. 28.) The number of points to the inch varies from 8 to 12.

The reason for this difference is that the wood fibers run lengthwise, and cannot be cut across smoothly except with a sharp knife point. A wider edge, like that of the teeth of a ripsaw, tears them apart and makes a rough and ragged cut. The wider-edged teeth, however, cut very smoothly in the same direction in which the fibers run, or with the grain. They also cut much faster than the teeth of a crosscut saw. This statement may be proved very easily and effectively by chiseling with and across the grain with a narrow chisel. A crosscut saw can be used to cut with the grain, but the work will proceed much slower than if a ripsaw is used.

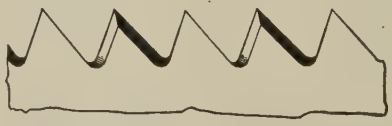


Fig. 28. Teeth of a crosscut saw

The sharpening of saws is described in Articles 111 to 114.

25. **The backsaw** is a crosscut saw with a thin blade and fine teeth. (Fig. 29.) A heavy piece of steel fitted over the back of the thin blade prevents it from buckling. The blades of backsaws are from 8 to 18 in.

Fig. 29. Backsaw

Fig. 30. Dovetail saw

long. Backsaws are used for finer work such as the cheek and shoulder cuts on tenons as described in Article 164.

26. **The dovetail saw** is shaped like a backsaw, but it has a thinner, narrower blade and finer teeth. (Fig. 30.) The handle of a dovetail saw is shaped like a chisel handle. The length of the blade varies from 6 to 12 in. It is used for extremely fine work such as the cutting of dovetails, as described in Article 171.

27. **The compass saw** is shaped like a ripsaw, but its blade is so narrow that it can cut on curved lines. (Fig. 32.) It is particularly useful in cutting a section from within a board or panel. A hole is bored near the line to be cut and the pointed end of the saw inserted in this hole.

28. **The keyhole saw** is a smaller and finer compass saw.

29. **The turning saw** consists of a very narrow blade, about $\frac{3}{16}$ in. wide, which is held under tension in a frame. (Fig. 31.) It has ripsaw teeth and is used for cutting curves, as the blade usually can be re-

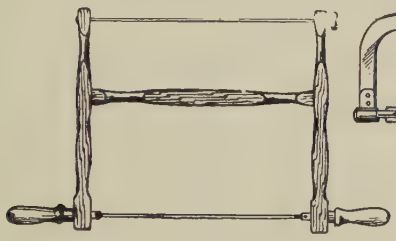


Fig. 31. Turning saw

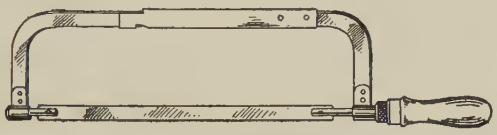


Fig. 33. Hack saw

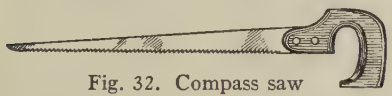


Fig. 32. Compass saw

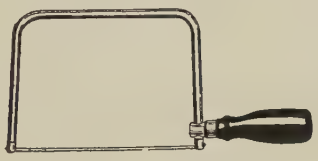


Fig. 34. Coping saw

volved in the frame. It can also be set in the frame so that it cuts either on the pulling or the pushing stroke.

30. **A hack saw** is not properly a woodworker's tool, but it is often a very convenient tool to have in the shop. It has a narrow blade set in a long, narrow metal frame, and is used for cutting metals. (Fig. 33.)

31. **A coping saw** is a very small turning saw usually having a metal frame. (Fig. 34.) It is used for sawing out fretwork patterns, and for coping moldings. (Art. 246.)

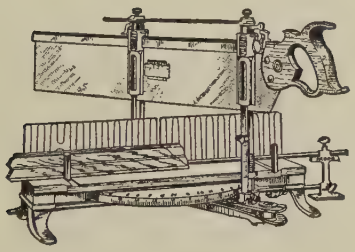


Fig. 35. Iron miter box

32. **Miter boxes** are made of either iron or wood. The iron miter box consists of a cast-iron frame fitted with a large backsaw, which is held perpendicular to the work by metal guides. (Fig. 35.) It can be adjusted to cut at any angle. It is used chiefly for mitering moldings and in picture-frame work. It is also very useful for cutting small pieces of wood at right angles.

PLANES

After measuring and sawing a piece of lumber to rough dimensions, it is generally planed to finished dimensions.

Planes, like saws, are made in many different forms for different planing jobs. Some of the most common types are as follows:

34. **The jack plane** is the most useful, all-around plane in the woodworker's kit. (Fig. 36.) It is 14 or 15 in. long, and consists of an iron body to which the plane iron can be clamped. The bottom of the plane, which is either smooth or corrugated, is called the "sole." The front part of the sole is called the "toe," and its rear part, the "heel." A casting, called the "frog," is screwed to the iron body near its center. A wooden knob is screwed to the forward part of the body, and a handle to its rear part.

Fig. 36. Jack plane

The plane iron, which in a jack plane is 2 in. or 2¼ in. wide, consists of two parts, the cutter and the cap. The latter is screwed to the back of the cutter, and is used to stiffen it and to break up the shavings. The plane iron is clamped to the frog by means of another iron, corresponding to the wedge in a wooden plane, called the "lever cap." The plane iron can be adjusted to the depth of the cut by means of a brass screw engaging a wishbonelike casting. This is called the "Y adjustment." It can be adjusted laterally or level with the sole of the plane, by a lever riveted to the top of the frog. (Fig. 37.)

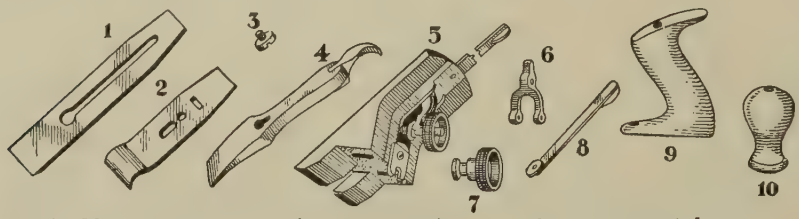


Fig. 37. Plane parts. 1, cutter iron; 2, plane-iron cap; 3, cap screw; 4, lever cap; 5, frog; 6, Y adjustment; 7, Y-adjustment screw; 8, lateral-adjustment lever; 9, handle; 10, knob

The sole of the plane keeps the thickness of the shaving uniform. If the board to be planed is uneven, it prevents the cutting iron from touching the hollow parts until all the high parts have been leveled off. Therefore, the longer the sole, the straighter the edge that is produced. The shavings enter through a narrow slit called the "throat" or "mouth." This slit is in the sole just forward of the cutting iron. The toe of the plane presses down on the wood in front of the shaving being taken, thus preventing it from splitting ahead. The width of the throat can be narrowed by moving the frog forward.

When planing an edge or a narrow board, the entire sole of the plane should be in contact with the wood to produce a straight edge. The tendency among beginners to hold the plane obliquely should be avoid-

ed and discouraged. Oblique cutting is a little easier, but it does not produce a flat surface, because only a small part of the sole is in contact with the wood.

35. **The fore plane** is built exactly like a jack plane, but is 18 in. long and has a plane iron 2⅜ in. wide.

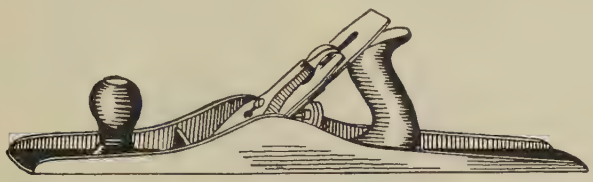


Fig. 38. Jointer

Fig. 39. Smooth plane

36. **The jointer** is also like the jack plane, but is 22 to 24 in. long, and has a plane iron 2⅜ or 2⅝ in. wide. (Fig. 38.) The latter two planes are used for leveling larger surfaces and for jointing the edges of boards to be glued.

37. **The smooth plane** is of the same construction as the above-named planes, but it is shorter, being from 5½ to 10 in. in length. (Fig.

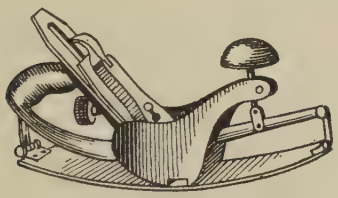


Fig. 40. Circular plane

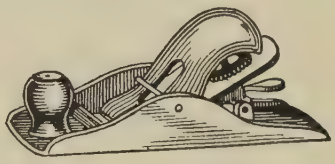


Fig. 41. Block plane

39.) It also has narrower plane irons, from 1¼ to 2 in. It is used for planing smaller pieces and for very fine work.

38. **The circular plane** differs from the others in that it has a flexible bottom 10 in. long, which can be adjusted to either convex or concave curves. (Fig. 40.) It is used on curved work, such as round table tops and aprons.

39. **The block plane** is a small plane from 4 to 8 in. long. (Fig. 41.) It has only a single plane iron, which is placed at a very low angle with the beveled side up. The lever cap is generally curved so that it fits smoothly within the hollow of the hand. This plane is used for planing end wood and in places where an ordinary plane could not be used.

40. **The bullnose rabbet plane** is about 4 in. long, and has the plane iron fastened to the extreme front of the body. (Fig. 42.)

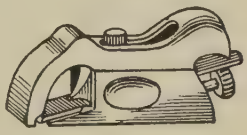


Fig. 42. Bullnose rabbet plane

41. **The rabbet and fillister plane** is an iron plane used for planing grooves or rabbets on the edges of a board. (Art. 146.) It has both a depth and a width gauge, as well as a spur, which scores the wood in advance of the plane iron, thereby preventing splitting. (Fig. 43.)

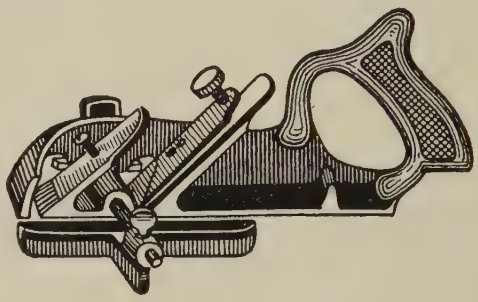


Fig. 43. Rabbet and fillister plane

42. **A dado plane** is similar to a rabbet plane, but is used for cutting across the grain.

43. **A matching plane** is used for matching boards; i.e., plowing a groove on the edge of one and a tongue on the edge of the other. It has two cutters, a plow and a tongue cutter. (Fig. 44.)

44. **The router plane** (Fig. 45) is used for removing the wood between two sawed or chiseled edges such as dadoes (Art. 147) or grooves. The plane iron is lowered after each cut. It is furnished with a ¼-in., a 2½-in., and a smoothing cutter.

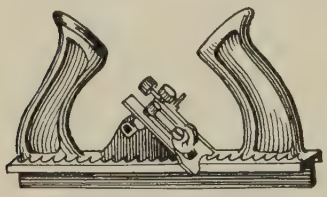


Fig. 44. Matching plane

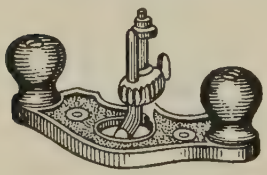


Fig. 45. Router plane

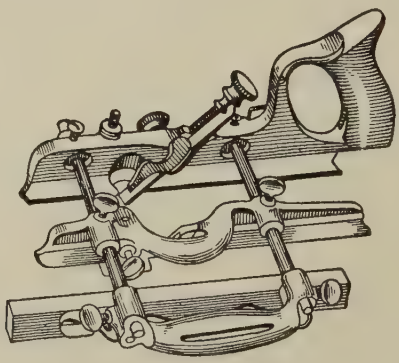


Fig. 46. Universal plane

45. **The universal plane** is a very complicated piece of apparatus for planing moldings, dadoes, beads, flutes, etc. It is furnished with as many as 53 different cutters. (Fig. 46.)

46. **Molding planes** are wooden planes, having but one plane iron for one particular type of molding.

Wooden planes of all types are still used a great deal, especially by European cabinetmakers and carpenters. The inexperienced worker finds them more difficult to adjust, but they have certain advantages over the

iron planes. One of these is lighter weight, which is especially noticeable on jointer planes, and another is that shavings from resinous woods do not stick to their bottoms.

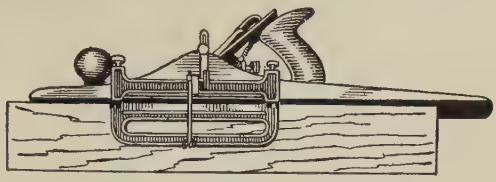


Fig. 47. Gauge attached to plane

47. Plane gauges are made both for iron and wooden planes. They can be attached to the sides of smooth, jack, fore, or jointer planes, and enable the operator to plane bevels or chamfers of any angle on the edge of a board without the continuous use of bevel or try-square. (Fig. 47.)

Fig. 48. Iron spokeshave

48. The spokeshave is like a plane with a very short bottom. (Fig. 48.) It is, therefore, suitable for smoothing curves that are too small for a circular plane. Spokeshaves are made in many patterns, generally with an iron body. One type, *the patternmaker's spokeshave,* is made of wood. (Fig. 49.)

The sharpening of plane irons is described in Article 115.

Fig. 49. Patternmaker's spokeshave

Fig. 50. Cabinet scraper

49. Scrapers are of two kinds; those sharpened like a plane iron and held in an iron frame or plane body (Fig. 50), and those that have square edges and are held in the hand only. The first class is called "cabinet scrapers" or "scraper planes," and the last type is called "hand scrapers." (Art. 118.) Hand scrapers having curved edges are called "molding scrapers."

Scrapers are used for smoothing a surface after it has been planed. Cross-grained and highly figured woods must always be scraped. As they usually can be planed only across the grain, the only tool that can be employed for smoothing them is a scraper. Veneers generally are not planed, but scraped.

All cutting and scraping should be finished before sanding. There is a good reason for this; for no matter how fine the sandpaper may be, tiny particles of quartz from the sandpaper become imbedded in the surface of the wood. This is not noticeable either to hand or eye; nevertheless these particles are sufficient to dull the edge of a sharp tool immediately.

The sharpening of cabinet and hand scrapers is explained in detail in Articles 117 and 118.

CHISELS

When a board has been planed to dimensions, the next operation usually is to join it to some other board or part of a structure. A chisel, in conjunction with other tools, is indispensable in the construction of most joints made by hand. It is indeed one of the most important and most used of woodworking tools.

According to their construction, chisels may be divided into two general classes: *tang chisels*, in which part of the chisel enters the handle, and *socket chisels*, in which the handle enters into a part of the chisel.

According to their use, chisels are divided into the following classes:

51. **The firmer chisel**, which has a strong blade, may be used for both heavy and light work. (Fig. 51.)

Fig. 51. Socket firmer chisel

52. **The paring chisel**, which has a slender blade, is used mainly for hand chiseling. (Fig. 52.) This type of chisel usually is beveled along the sides, so that fine work can be done, such as reeding (Art. 236) which requires an extra-thin blade.

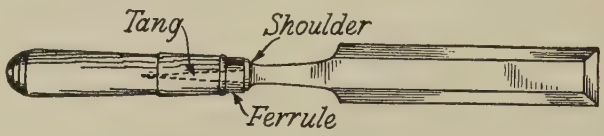


Fig. 52. Tang paring chisel

53. **The framing chisel** has a very heavy and strong blade, and is used in rough carpentry work and shipbuilding.

54. **The butt chisel** differs from the others only in that it has a shorter blade and, therefore, can be used in more inaccessible places.

The above-named chisels are made in widths of from ⅛ to 2 in.

55. **The mortise chisel**, as its name implies, is used for chiseling mortises. It is, therefore, very thick just below the handle so that it will not break when it is used as a lever in forcing the shavings out of the mortise. (Fig. 53.)

Fig. 53. Socket mortise chisel

If the mortise is bored, it may be cleaned out and squared with an ordinary firmer chisel as described in Article 164.

The parts of a chisel are: the blade, on the end of which one bevel is ground; the shank, which is the upper narrow part of the blade; the socket, which is the end of the blade, shaped like a hollow cone, and in which the tapered end of the wooden handle fits. In tang chisels, the shank ends in a sharp point called the "tang," which is driven into the end of the handle. A projection on the shank, called a "shoulder," butts against the end of the handle and prevents the tang from entering further. A brass or iron ring, called the "ferrule," fits on the lower end of the handle and prevents it from splitting. Chisel handles are often leather tipped to protect them from the blows of the mallet.

56. **Gouges** are like chisels, except that their blades are bent lengthwise, so that in cross section they appear as a part of a circle. If the bevel is ground on the convex side, they are called "outside-bevel

Fig. 54. Outside-bevel gouge

gouges" (Fig. 54), and if it is ground on the concave side, they are called "inside-bevel gouges." Some inside-bevel gouges have a bent shank, which is of advantage in giving room for the hand. This type of gouge is called "bent-shank gouge." (Fig. 55.)

Fig. 55. Bent-shank gouge

57. **Carving tools** (Fig. 56) are made in numerous different shapes. Many of these are gouges of different diameters and bend, others are chisels, but having two bevels; and still others have their blade bent lengthwise into a sharp angle, and are known as "veining tools." Veining tools are very useful, not only for wood carving, but also for two toning. (Art. 250.) The sharpening of chisels is described in Article 115. For description of turning chisels and how to sharpen them, see Article 120.

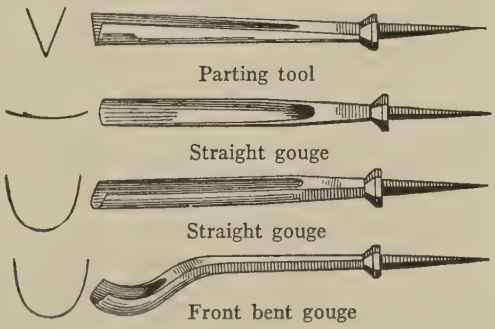


Fig. 56. Carving tools

58. **The drawknife** is used for rough cutting, especially on edges, both

straight and curved. It is a tool with a long blade whose cutting edge is on the side. At each end of the blade is a handle. (Fig. 57.) The operator grips the handles and draws the knife toward him.

BORING TOOLS

The woodworking and metal trades distinguish sharply between bits and drills and between boring and drilling.

Woodworkers never say that a hole is *drilled* in wood, but use the term *bored* instead.

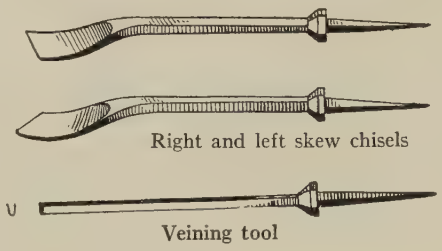


Fig. 56. Carving tools

The woodworker uses bits for boring holes for screws, dowels, and hardware, as an aid in mortising and in shaping curves and for many other purposes. As was the case with saws, planes, and chisels, bits vary in shape and structure with the type of work to be done. Some of the most common bits are the following:

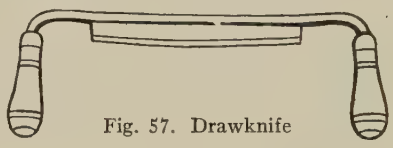


Fig. 57. Drawknife

59. Auger bits are screw-shaped tools consisting of two main parts, the twist and the shank. (Fig. 58.) The twist ends in two sharp points, the nibs or spurs, which score the circle, and two cutting edges, the lips, which remove the shavings from within the scored circle. A small screw point, in the center of the cutting end, centers the bit and draws it into the wood. (Fig. 59.) The threads of this screw are made in three different pitches, steep, medium, and fine. The steep pitch means quick boring and thick chips, and the fine or slight pitch means slow boring and fine chips. For end-wood boring, a steep- or medium-pitched screw should be used.

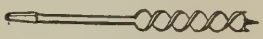


Fig. 58. Auger bit

The shank ends in a square-tapered tang, which is held by the chuck of the brace. The sizes of auger bits are indicated in sixteenths of an inch and are stamped on the tang. Number 10 means, therefore, $^{10}/_{16}$ or $^{5}/_{8}$ in.; 4 means $^{4}/_{16}$ or $^{1}/_{4}$ in., and so on. Auger bits are made in sizes from $^{3}/_{16}$ to 2 in. by sixteenths of an inch. The common woodworker's set ranges in size from $^{3}/_{16}$ to 1 in.

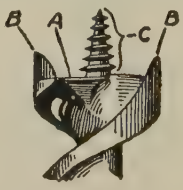


Fig. 59. End of auger bit
A, lips; B, nibs; C, screw or spur

60. Dowel bits are short auger bits $4^{1}/_{2}$ in. long over-all. Ordinary auger bits up to 1 in. diameter are from 7 to 9 in. long over-all.

61. Car bits and ship augers are auger bits from 18 to 24 in. in length.

62. **Expansive bits** have a movable cutter, which is adjustable to bore holes of different diameters. (Fig. 60.) Expansive bits are made

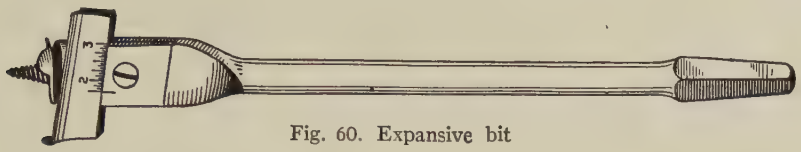


Fig. 60. Expansive bit

in two sizes. The largest size has three cutters, and bores holes up to 4 in. in diameter.

63. **Gimlet or German gimlet bits** (Fig. 61) are used for boring holes of small diameters such as are needed when inserting screws in hard wood. (See Art. 198.) Their size, which varies from $\frac{1}{16}$ to $\frac{3}{8}$ in. by thirty-seconds, is stamped on the tang.

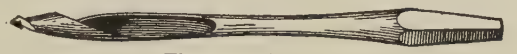


Fig. 61. Gimlet bit

64. **Twist bits** are shaped just like the familiar *twist drill*, except that they have a steeper cutting angle and a square tang. (Fig. 62.) They range in size from $\frac{1}{16}$ to $\frac{5}{8}$ in. by thirty-seconds. Twist bits can be used for wood only, while twist drills can be used for both wood and metal.

Fig. 62. Twist bit

65. **Forstner bits** have no twist and no spur. They cut with a sharp circular steel rim and two lips within this rim. (Fig. 63.) They bore very accurately, and are especially useful for boring thin wood and for endwood boring. Their sizes are stamped on the tangs in sixteenths of an inch.

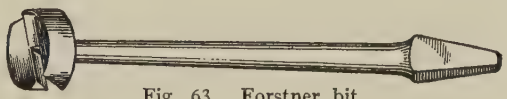


Fig. 63. Forstner bit

66. **The bradawl** has the appearance of a small screw driver. (Fig. 64.) It is used for making holes into wood for screws and nails. The hole is produced by forcing the awl into the wood with a twisting motion. It should not be used in thin wood nor too near the edge.

Fig. 64. Bradawl

Fig. 65. Rose countersink

67. **The countersink** is a small, cone-shaped tool used for widening the end of holes bored for flathead screws. (Fig. 65.) One type can be opened and sharpened on an oilstone.

68. **Plug and washer cutters** (Fig. 66) are used to cut circular disks from wood or leather. Such small disks are sometimes used to plug up holes in wood.

69. **The plain brace** is a tool used for holding a bit securely while boring a hole. At one end the brace has a chuck for clamping the bit;

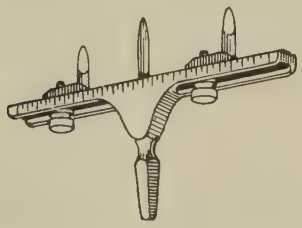


Fig. 66. Washer cutter

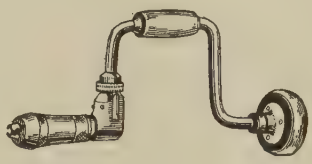


Fig. 67. Ratchet brace

at the other, a knob. The handle of the brace is shaped like a crank.

70. **The ratchet brace** (Fig. 67) is fitted with an attachment which permits of boring in places where a complete turn cannot be made. The size of braces is given according to the *sweep*; i.e., the diameter of the circle that the handle makes in a complete revolution.

Fig. 68. Bit-brace extension

71. **A bit-brace extension** is a steel rod having a small chuck on one end and a square shank like a bit on the other. (Fig. 68.) A bit, ⅝ in. or more in diameter, is inserted into the chuck of the extension, and this in turn into the chuck of the brace. The smallest hole that can be bored with this tool measures ⅝ in. Bit-brace extensions are made from 12 to 21 in. in length. The smallest hole that can be bored with the larger size measures ¾ in.

72. **Auger-bit gauges** of different types can be fastened to auger bits, and adjusted so that only holes of certain depths are bored. (Fig. 69).

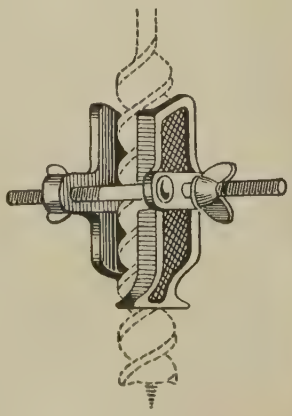


Fig. 69. Auger-bit gauge

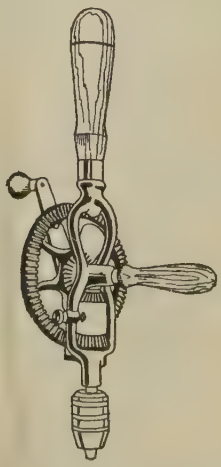


Fig. 70. Hand drill

73. **Automatic drills, reciprocating drills, and hand drills** are used by many woodworkers for rapid boring of small-size holes. A magazine for small drill points usually is found in the handle of these tools. (Figs. 70 and 71.) Only straight-shank drills can be used in these tools.

Fig. 71. Automatic drill

MISCELLANEOUS TOOLS

75. **Plain screw drivers** are made with blades from 2 to 18 in. in length. The blades in the better grades are welded to a long steel ferrule, thereby preventing the possibility of turning in the handle. (Fig. 72.) A long screw driver is more powerful than a short one, because the long handle gives more leverage.

Fig. 72. Screw driver

76. **Automatic screw drivers** are built on the same principle as automatic drills. A ratchet arrangement permits them to drive in one direction and release in the other. The best types can both drive and withdraw screws. They can also be locked so as to act as plain screw drivers.

77. **Screw-driver bits** are screw-driver blades, the upper ends of which have been forged to a square, tapered shank. (Fig. 73.) They are used with a brace. These bits are 5 in. long and from ¼ to ½ in. wide at the point.

78. **The claw hammer** is the type of hammer generally used by carpenters and woodworkers. The peen of this hammer is bent and shaped so that it can be used for pulling nails. (Fig. 74.) The face of the hammer often is slightly convex, or bell-faced, so that it will not make a cir-

Fig. 73 Screw-driver bit

Fig. 74. Claw hammer

cular mark on the surface of the wood after striking the last blow on the head of a nail. It is important to keep the face of the hammer clean and free from grease or glue, so that it will not glance off the head of a nail and bend it. The size of the hammer is indicated by the weight of the head in pounds and ounces.

79. **Nail sets** are small steel bars about 4 to 5 in. long and ¼ in. in diameter. (Fig. 75.) They have a cup-shaped point, and are used to set nails below the surface. The size of the point varies with the size of the nail to be set.

Fig. 75. Nail set

80. **Mallets** are wooden hammers. (Fig. 76.) As wood is more elastic than iron or steel, a mallet should always be used when driving on wood. The blows of a steel hammer would soon splinter a chisel handle and mar a joint to be driven together beyond repair.

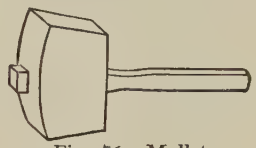


Fig. 76. Mallet

81. **Hatchets** are used chiefly by carpenters in shingling and lathing. They have a short handle and can be used both for cutting and nailing. (Fig. 77.)

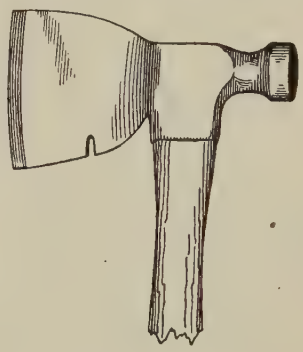


Fig. 77. Hatchet

82. **Rasps and files** are used by the woodworker for reducing and smoothing edges that cannot be worked with a cutting tool. Saw files and auger-bit files also are used for sharpening saws and auger bits and the point on marking gauges.

Files are made in more than three thousand different varieties. They have teeth or serrations of various degrees of fineness and pattern, cut diagonally across their surfaces. Rasps have triangular projections, and cut much faster than files.

To clean a rasp or file see Article 127.

Files are used in many different trades and for many different purposes. They are classified according to the shape of their cross section, as square, round, triangular, flat, half round, etc.; according to the manner in which the serrations or teeth are cut, as single cut (oblique parallel lines across the surface), double cut (two sets of parallel lines

Fig. 78. Half-round wood file

crossing each other obliquely), and open cut (oblique parallel lines, slightly broken); according to fineness of cut, as coarse, bastard, second cut, smooth, and dead smooth; according to length (not including the tang) usually from 3 to 14-in.; and according to outline, as blunt (having the same cross section throughout), and taper. (Figs. 78 and 79.)

Fig. 79. Single-cut auger-bit file

The surface of rasps is covered with rough, triangular points or projections, called "teeth." (Fig. 80.) Rasps cut faster but rougher than files. They should, therefore, be used before files.

The use of rasps or files on wood should be discouraged, except on spe-

Fig. 80. Rasp

cial work as chairmaking or where it is impossible or impractical to use a cutting tool.

The woodworker also uses various saw files, usually triangular, for sharpening saws, and the auger-bit file for sharpening auger bits. (Fig. 79.)

Clamps for holding the work together while gluing are made in various sizes and of several kinds. The most important are: bar clamps, C clamps, column clamps, and hand screws.

83. Steel bar clamps consist of a steel beam or bar fitted with a screw and crank at one end, and a steel head which can be moved along

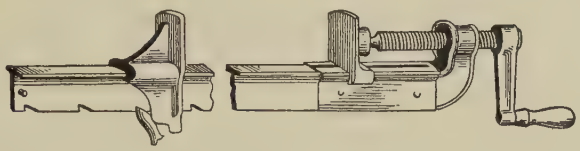


Fig. 81. Steel bar clamp

the bar and fastened to it by means of slots cut into its lower edge at short intervals. (Fig. 81.) Steel bar clamps are made in lengths of 2, 2½, 3, 4, 5, 6, 7, and 8 ft. (Arts. 189, 191, 193, and 194.)

84. C clamps, or screw clamps, sometimes called "carriage-maker's clamps," consist of a malleable-iron frame, bent in the shape of the letter C, and a steel screw with a swivel tip. (Fig. 82.) They are made in sizes, which, when open, measure from 3 to 12 in.

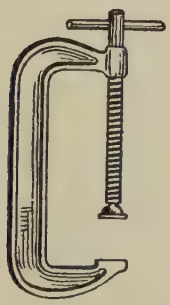


Fig. 82. C clamp

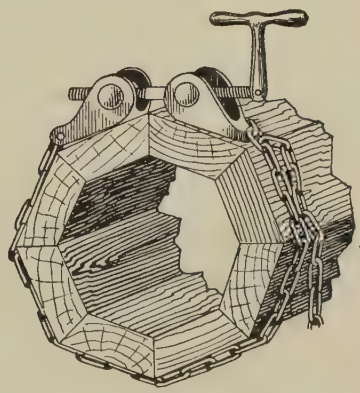


Fig. 83. Column clamp

85. Column clamps consist of a steel chain and a right and left screw. (Fig. 83.) They are very useful when gluing together polygons, shaped columns, and any circular work such as the apron for a round table.

86. **Hand screws** are most useful both in clamping up finished work and in holding work under construction. (Arts. 139 and 195.)

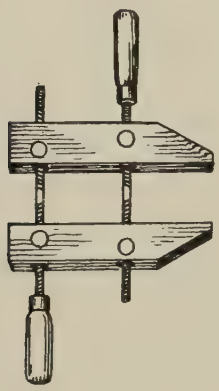


Fig. 84. Hand screw

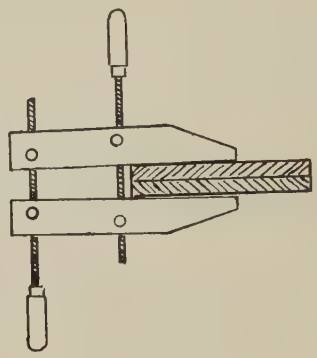


Fig. 85. Tightening hand screw

They consist of two jaws made of hard wood and two steel spindles, the end and middle spindles. (Fig. 84). They are opened or closed by grasping a handle in each hand and revolving the hand screw. The size of a hand screw is indicated by the length of the jaw in inches, the smallest being 6 in. and the largest 18 in.

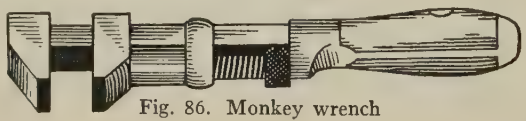


Fig. 86. Monkey wrench

When tightening up hand screws on straight work, the middle spindle should first be tightened so that the jaws hold firmly at that point, but are a little open at the end. (Fig. 85.) When the end spindle is now tightened, the jaws will come together at the end and be parallel.

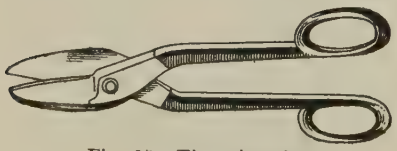


Fig. 87. Tinner's snips

Fig. 88. Side-cutting pliers

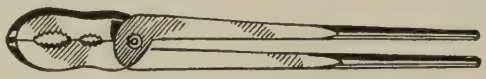


Fig. 89. Gas pliers

87. **A monkey wrench (Fig. 86), tinner's snips (Fig. 87), cutting pliers (Fig. 88), or nippers and gas pliers (Fig. 89),** although not woodworkers' tools, will be found very convenient and useful in the woodworking shop.

REVIEW QUESTIONS

Measuring Tools

1. Why is a bench top made of narrow pieces of wood?
2. Compare rules and measuring tapes as to length, divisions, and use.
3. What is the difference between try-squares, miter squares, and sliding T bevels?
4. What are the parts of a steel square and the dimensions of each part?
5. Name five operations for which the steel square is used.
6. Describe the use of the octagon scale. On which part of the steel square is it found?
7. Find the number of board feet in a plank 2 in. by 10 in. by 15 ft. 0 in., (*a*) by calculation, and (*b*) by using the board-measure scale.
8. Explain the terms run, rise, and pitch, and the relation of one to the other.
9. Find the length of a common rafter if the run is 15 ft. 0 in., and the rise 10 ft. 0 in.
10. What is the difference between a panel gauge and a slitting gauge?
11. What are the parts of a marking gauge?
12. How does a mortising gauge differ from a butt gauge?
13. What tool would you use for laying out (*a*) a curve having a radius of 4 in., and (*b*) a circular table top 36 in. in diameter?
14. What is a spirit-level glass, and in what tool is it used?
15. What is the shape of a plumb bob, and how is it used?

Saws

16. What specifications must be given when buying a saw?
17. Differentiate between the teeth of a ripsaw and a crosscut saw.
18. What is the meaning of the word "points" as applied to saws?
19. What type of saw should be used for the following operations:
    a) Cutting four pieces 2 by 2 by 30 in. from a plank 2 in. by 12 in. by 15 ft. 0 in.
    b) Cutting a circular opening 5 in. in diameter in a board ⅞ in. by 10 in. by 5 ft. 0 in.
    c) Cutting a circular table top 30 in. in diameter.
    d) Cutting a shoulder on a tenon.
    e) Cutting an intricate design in the center of a ½-in. panel 12 in. square.
20. Describe a miter box, and explain its use.
21. For what is a hack saw used?

Planes

22. What is the principal difference between smooth, jack, fore, and jointer planes?
23. Name and describe the principal parts of a jack plane.
24. What is the proper plane to use for the following operations:
    a) Planing the ends of a piece 2 in. wide.
    b) Planing edges, faces, and ends of a board ⅞ by 10 by 20 in.
    c) Planing the edges of two boards 4 ft. 0 in. long that are to be glued.
    d) Removing the surplus wood from a dado joint whose edges have been sawed or chiseled.
    e) Planing the edge of a circular table top 36 in. in diameter.
    f) Planing a groove on the edge of a board.
    g) Planing a molding.
    h) Planing a rabbet on a picture frame.
25. How does the use of a spokeshave differ from that of a circular plane?
26. What is a plane gauge? How is it used?

27. What is the difference between a cabinet scraper and a hand scraper?
28. Why should all planing and scraping be completed before sanding?

Chisels

29. What is the difference between a socket and a tang chisel?
30. Why is there a metal ring around the handle of a tang chisel?
31. Name the most common chisels, and indicate the chief use of each.
32. How does a gouge differ from a chisel as to shape and use?

Boring Tools

33. What is the difference between a bit and a drill?
34. What is the function of each of the following parts of an auger bit: spur, nibs, lips?
35. How is the size indicated on auger bits, Forstner bits, twist bits, and gimlet bits?
36. What type of screw point should be used for boring in end wood with an auger bit?
37. What kind of boring tools should be used for the following operations:
    a) To bore for a ½-in. dowel.
    b) To bore for a 1½-in. flathead screw.
    c) To bore a hole 1¾ in. in diameter.
    d) To bore in end wood.
    e) To bore a hole ½ in. in diameter and 16 in. long.
    f) To bore a hole ¾ in. in diameter and 16 in. long.
    g) To bore for a ½ by 4-in. roundhead screw.
    h) To bore a 7/16-in. hole in ¼-in. stock.
    i) To cut a circular leather disk 2 in. in diameter.
38. What is understood by the word "sweep" as applied to braces?
39. What is an auger-bit gauge, and how is it used?
40. What is a hand drill?

Miscellaneous Tools

41. Why is it easier to drive a large screw with a screw driver 18 in. long than with one 8 in. long?
42. What is the chief advantage of (*a*) an automatic screw driver, and (*b*) a screw-driver bit?
43. What advantage has a "bell-faced" hammer over a common hammer?
44. Compare the blows of a hammer with those of a mallet.
45. What is the shape and use of a hatchet?
46. What is the difference in shape and use between a rasp and a file for wood?
47. Differentiate between carriage-maker's clamps, bar clamps, and column clamps.
48. What are the parts of a hand screw?
49. How is a hand screw applied and tightened on a piece of work?
50. Name five jobs for which a woodworker may have to use one or more of the following tools: monkey wrench, tinner's snips, cutting pliers, gas pliers.

CHAPTER II

MACHINE TOOLS

During recent years there has been considerable progress in the field of woodworking machinery. Particular attention has been given to greater safety for the operator, and to convenience and ease in both the "setting up" and the operation of the machinery. Old types of production machines have been improved, and new types have been invented. Moreover, numerous types of bench and portable machines have been developed.

Since woodworking machinery is very dangerous to operate, improvements and inventions that will safeguard the operator are of the greatest importance. Some of the most notable advances have been cylindrical cutting heads on hand planers, safety switches, improved guarding devices, and the elimination of fast-moving belts through direct motor drives.

Developments within the field of production machinery have completely revolutionized the furniture industry, and have made cabinet-making in its century-old form one of the disappearing trades. In large furniture factories, handwork has been reduced to a minimum, because machines have been invented which can be operated by semi-skilled workers. Such machines perform practically all tool operations faster, better, and more uniformly than the skilled workman can by hand methods.

While a discussion of production machinery is interesting, both from a mechanical and a commercial point of view, it has no place in this book, which deals mainly with handwork, hand tools, and the simpler and more commonly used woodworking machines and operations.

The development of the small bench and portable machines, on the other hand, is of interest to the manufacturer and the individual workman, as well as to students of woodworking, and the increasing number of amateurs, who find recreation, satisfaction, and joy in manual work. Large up-to-date factories have found it to their advantage to distribute a number of these small machines among their benchworkers, because they help to speed up production by eliminating practically all handsawing and planing.

For the same reasons, contractors and individual workmen use them in increasing numbers, not only for sawing and planing, but also for routing, shaping, boring, and sanding.

This type of machinery has also become very popular in schools, es-

pecially those of junior grade where the work done is usually limited to size.

A special type of combination machine is very popular with the home craftsman. This machine usually consists of a small lathe as the basic tool, to which can be added attachments for boring, sawing, grinding, buffing, jig sawing, etc. (Fig. 90.)

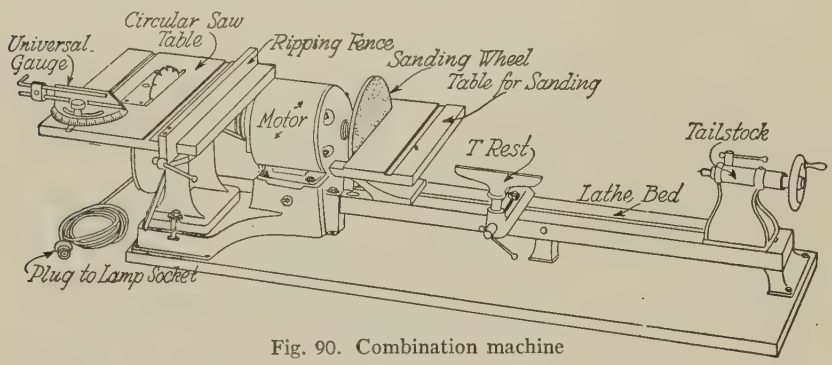


Fig. 90. Combination machine

A well-equipped woodworking shop contains the following machines: a swing cut-off saw, a circular saw, a band saw, a jig saw, a jointer, a planer, a mortiser, a shaper, a sander, a trimmer, a lathe, and sharpening machines.

89. **Swing cut-off saws** are of two general types, those which cut from above and those which cut from below.

Those of the first type consist of a hollow cast-iron column, suspended from two hangers fastened either to the ceiling or to the wall. A casting, the arbor frame, containing the bearings in which the saw arbor runs, is bolted to the end of this frame. Slots in the arbor frame permit a vertical movement. (Fig. 91.)

The motive power is transmitted in one of three different ways, by a countershaft, by a belted motor drive, and by a motor-on-arbor drive.

The countershaft has three pulleys, a tight and loose pulley of the same diameter, and a driving pulley of a larger diameter. (Fig. 267.)

A belt from the driving shaft runs on the loose pulley, which revolves on the countershaft without moving it. When the belt is shifted over to the tight pulley, which is keyed and bolted to the countershaft, the latter starts to revolve. The driving pulley, which is also bolted to the countershaft, drives the saw arbor by means of a belt at about 2000 r.p.m.

The belted motor drive consists of an individual motor mounted on the frame of the saw in place of the countershaft and belted to the saw arbor.

In these two machines, provision is made for tightening the belt

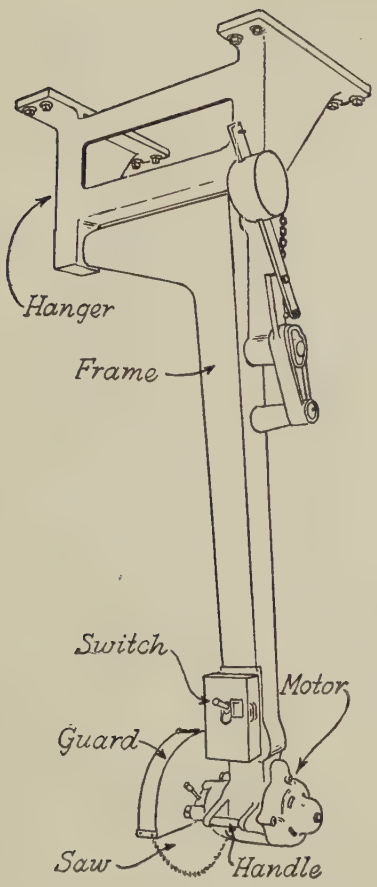


Fig. 91. Swing cut-off saw

by a vertical movement of the saw-arbor casting.

The motor-on-arbor drive is one of the newest types. In this a ball-bearing motor is built on the arbor of the saw. A safety switch is conveniently mounted on the column above the motor. (Fig. 91.)

The saw table consists of two sections, each about 8 ft. long, 20 in. wide, and 30 in. high. The top usually is made of hard wood and is supplied with rollers to facilitate the moving of long planks or timbers. It also is furnished with a scale graduated in inches and feet, and iron stops. (Fig. 93.)

The saw swings in the narrow opening between the two tables, and is adjusted so that its teeth come just below the surface of the table. Readjustment is necessary after the saw has been worn and filed to a smaller diameter. Another type of swing cut-off saw, which also cuts from above, is mounted on a vertical cast-iron column somewhat resembling that of a mortising machine. (Fig. 92.) This machine is very rigid and accurate, and can be set to cut different angles.

90. Use of swing cut-off saw. This type of saw is used mainly for dadoing, and for cutting boards, planks, or timbers into required lengths. If a number of pieces are to be cut the same length, one of the iron stops is adjusted accordingly, and the lumber is pushed against it. By means of a handle bolted to the arbor casting, the saw is then pulled across the board or plank. A heavy counterweight causes the saw automatically to swing out of the way after the operator releases the handle.

The saws used are from 12 to 24 in. in diameter, and the capacity is 12 in. in width and as much as 9 in. in thickness. The saws are guarded

with an aluminum casting and the belts with wire mesh guards.

91. The under-swing cut-off saw consists of an iron saw table similar to that of a circular saw with wooden extensions, one to each side. The extensions are provided with rollers and automatic stops. The saw arbor is placed in a swinging frame below the table and is moved forward, across the board or plank to be cut, by means of a foot pedal. When this pedal is released, counterweights automatically throw the saw back to its first position. (Fig. 93.)

The advantage of this type of saw over the one described above is that it leaves the operator's hands free, and consequently gives him greater control over the material he handles.

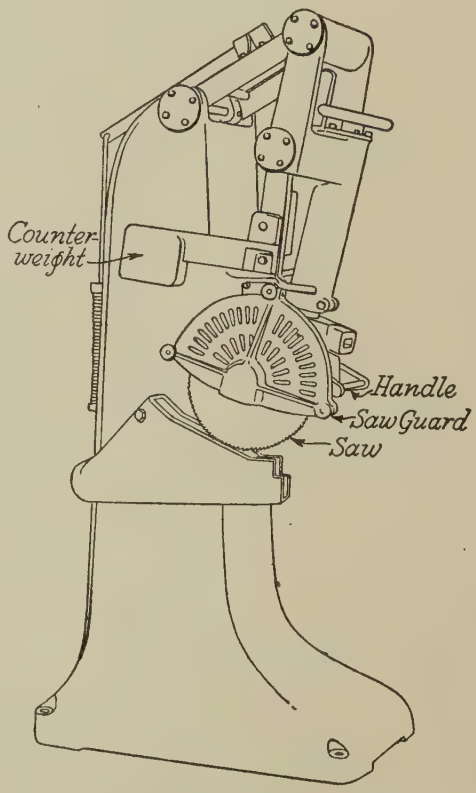


Fig. 92. Swing cut-off saw on column

The stroke of the saw may be lengthened or shortened as desired. The saw may also be clamped in one position and used as a ripsaw.

It is driven by means of a countershaft or individual motor belted to the saw arbor. An idler, which is simply a weighted pulley, keeps the belt tight at all positions of the saw.

92. The circular saw is, no doubt, the most useful and indispensable of woodworking machines. Besides numerous sawing operations, for which this machine is especially suitable, many other operations, such as edge planing, shaping of moldings, cutting of grooves, rabbets and tenons, and, in some cases, boring and mortising, may be done on the circular saw.

A circular saw consists of a heavy casting to which an iron table with a smooth, level surface is fastened. The universal circular saw, Figure 94, has two saw arbors supported on a saw-arbor yoke, which can be revolved by means of a handwheel, both when the machine is stationary and in motion. Two saws, therefore, can be used on this machine

at the same time, and either one brought into action when desired. Each saw can be adjusted and clamped at different heights above the table.

The modern circular saw usually is driven by an individual motor screwed to a cast-iron base, which in turn is bolted to the frame of the saw. An endless belt passes over the pulley of the motor and the two saw-arbor pulleys, and is held under tension by means of a weighted idler pulley. The speed of the arbors should be about 2500 r.p.m.

The table consists of two parts, the larger of which is stationary and the smaller movable both lengthwise and crosswise. The lengthwise movement past the saw is for the purpose of crosscutting wide boards. The table is made to move as easily as possible by mounting it on roller bearings. The crosswise movement is simply for the purpose of changing saws and for making room for thick grooving saws, dado and molding heads. The threads on the arbors are "left hand." The nuts, which clamp the saws, must therefore be loosened by turning them to the right or clockwise.

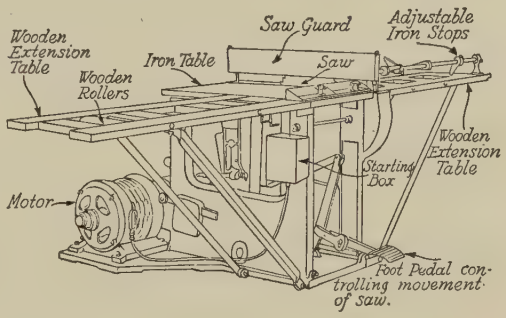


Fig. 93. Under-swing cut-off saw

The movable part of the table can instantly be clamped in a fixed position, and the whole table may be tilted from the horizontal position to any angle up to 45 deg.

A universal saw usually is equipped with four types of fences or gauges, for ripping, crosscutting, mitering, and segment work.

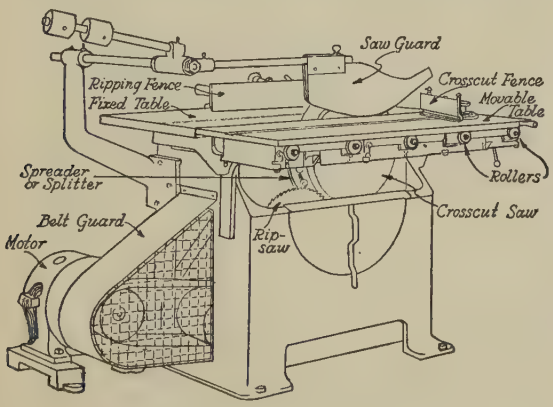


Fig. 94. Circular-saw

The ripping fence is a heavy casting, which may be fastened to the saw table on either side of the saw. It is used mostly on the stationary part or right side of the table. It is fastened parallel to the line of the saw for ordinary ripping, and may be tilted to any angle between 45 and 90 deg. It may be easily and quickly adjusted to rip any width up to 26

in., depending upon the size of the machine. Some machines are fitted with a very accurate micrometer adjustment.

The ripping fence is used for any lengthwise cutting such as ordinary ripping, grooving, rabbeting, or shaping straight moldings.

The miter cut-off gauge is used for crosscutting or mitering wide boards, and is fastened near the end of the movable table. It is instantly located at right angles to the line of the saw by means of pins fitting into corresponding holes drilled in the table.

When cutting a number of short pieces, it is generally used in conjunction with the ripping fence. An iron block is screwed to the end of the latter which is then fastened at the correct distance to the right of the saw. The piece to be cut is held with an edge against the cut-off gauge and the end butting against the iron block. When the table is pushed past the saw, the piece is cut off and left lying on the stationary part of the saw table, there being sufficient clearance between the saw and the ripping fence to prevent it from binding and being thrown backward by the saw. (Fig. 95.)

When longer pieces are to be cut, a square steel rod is clamped in a corresponding groove in the face of the gauge. It projects beyond the saw table to the left of the operator, and is furnished with an iron stop, which is set at the required distance to the left of the saw. (Fig. 96.) In this "set-up," the ripping fence should be removed so that the saw

Fig. 95. Cutting short pieces to length on circular saw. The guard has been removed in order to make the operation more clear. Sawing should never be done without the guard in place

table is left entirely clear. The pieces cut off fall to the left of the saw and are usually removed by an assistant. Stop blocks and length gauges also may be made of wood, as shown in Figures 95 and 96.

The miter cut-off gauge can be adjusted to any angle from 30 to 135 deg.

The universal gauge is a smaller cut-off gauge, which runs in shallow

Fig. 96. Cutting long pieces to length on circular saw. The guard has been removed in order to make the operation more clear. Sawing should never be done without the guard in place

grooves cut in the face of the table. Two of these gauges, which can be set to any angle between 30 and 135 deg., are usually furnished with the saw. They can be used on either side of the saw, and are particularly useful for mitering or crosscutting small pieces. Compound miters are cut by using these gauges while at the same time tilting the table to the correct angle. When not in use, the grooves are filled with steel strips, so that the table presents one smooth, level surface.

The segment gauge is similar to the universal gauge, but is furnished with locating points against which the segments are placed. A scale for determining the angle, length, and number of segments in any circle from 10 to 80 in. is engraved on the saw table. (Fig. 97.)

Full directions for using the various gauges are furnished by the manufacturers.

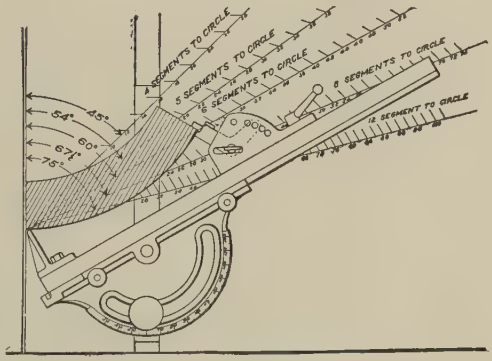


Fig. 97. Segment-gauge drawing

The cutting tools used on a circular saw are ripsaws, crosscut saws, miter saws, dado heads, straight and shaped molding cutters.

The teeth of circular ripsaws and crosscut saws are shaped very much like those of the corresponding handsaws. The miter saw has a series of about half a dozen crosscut teeth alternating with a ripsaw tooth all around its circumference. It makes a very fine, clean cut. When ordering any one of these saws, the following specifications should be

given: kind of saw, as rip, crosscut, etc., diameter of saw, gauge or thickness, and diameter of arbor hole. (Fig. 98.)

Grooving saws are thick saws designed to cut grooves in wood.

A dado head consists of two saws or outside cutters, and a number of inside cutters of various thicknesses which may be placed between

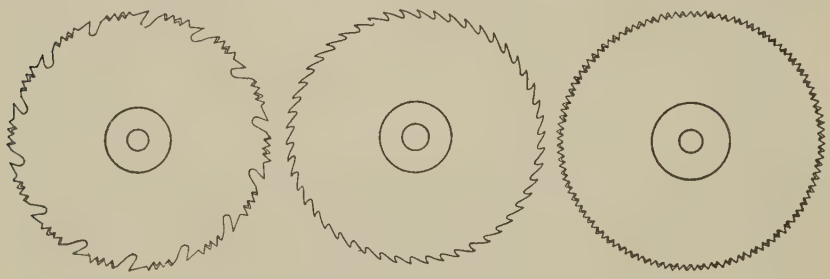


Fig. 98. Crosscut saw, ripsaw, and miter saw

these. Grooves of from 1/8 to 2 in. in width can be cut with a dado head. The outside cutters have a combination of rip and crosscut teeth, and cut equally well with or across the grain. (Fig. 99.) A dado sleeve and collars are furnished with the dado head.

93. **Directions for setting up a dado head.** In setting up a dado head, proceed as follows: Screw the dado sleeve to the saw arbor, and

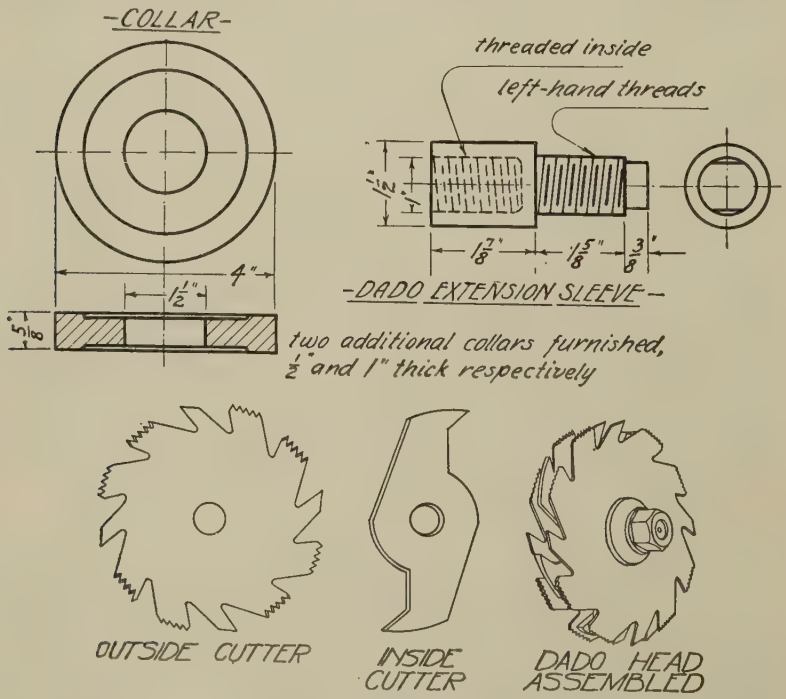


Fig. 99. Dado head

slip on one of the outside cutters or saws. Note that the arbor holes in the cutters and collars are larger than on the regular saw and collar. Select the inside cutters, which, together with the two saws, will make up the desired thickness (for example, to cut a groove ¾ in. wide). Space these inside cutters so that their teeth are about the same distance apart. Slip on the other saw or outside cutter, press the whole together with the hand, and check thickness measurement. The collars are now placed on the sleeve. Be sure that the last collar projects over the shoulder of the dado sleeve. Put on the regular collar and nut, slide the saw table in position, and fasten it. Turn the dado head by hand to see that it is clear. Adjust it to height above the table, turn on the power, and make a trial cut. If it is necessary to readjust for width, this can often be done by inserting a small cardboard washer between the cutters. Narrow dadoes may be cut without the dado sleeve extension. The cutters have thus the regular arbor hole and are used on the regular saw mandrel.

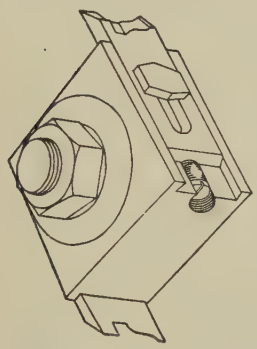


Fig. 100. Grooving head for shaping moldings

A grooving head is a solid casting, to which may be fastened straight knives for edge planing or curved ones for molding work. (Fig. 100.) Grooving heads also are circular in shape.

Other circular saws have only one arbor; some are used only for ripping, and others for a variety of work. One type of "variety saw" has a motor-on-arbor drive, the other end of which is fitted with boring and mortising attachments. (Fig. 101.) Other types are fitted with jointing and sanding attachments. Circular saws are also manufactured for bench use. These small machines are remarkably complete and efficient for small work.

93*a*. Directions for using the circular saw. A circular saw is one of the most dangerous machines made, and should never be operated by nervous or careless persons. A real foolproof guard that can be used under all conditions has unfortunately not yet been invented. The guard furnished is often in the way and must be moved for measuring and for certain types of cutting. Therefore many operators, unless compelled to use the guard, get into the habit of using the saw without it. The following general directions and cautions in using the saw are recommended:

1. Do not use a saw which is not properly sharpened or set. Lack of set often results in pieces being thrown back with great violence, or in overheating the saw. Blue patches, called "bull's eyes," are formed when the saw binds and gets too hot. As these patches are always slightly convex on one side, the saw will no longer make a smooth,

even cut. It should then be sent to the factory for retempering. (See Sharpening Circular Saws, Arts. 128 to 132.)

A spreader, which is a thin piece of steel fastened behind the saw,

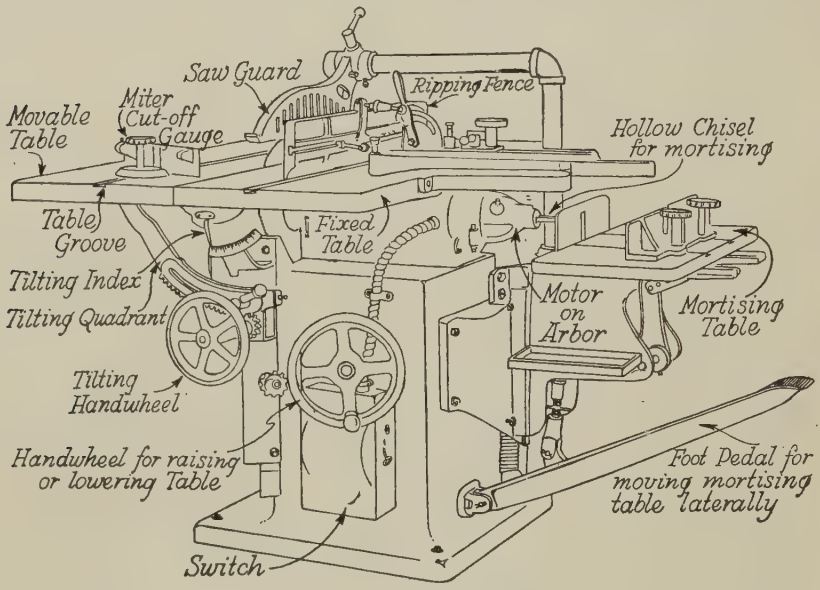


Fig. 101. Variety saw bench

prevents the saw kerf from closing and pinching the saw, thereby largely eliminating the danger of "kick back."

2. Stand to the left of the saw to avoid being hurt by pieces that may be thrown back by the saw.

3. Adjust the saw so that it projects only about 1/8 in. over the piece of lumber being cut.

4. Use the guard whenever possible, and do not reach over the saw.

5. Use a forked stick for pushing the wood between the saw and the ripping fence when ripping narrow pieces, or cut halfway through from one side and then reverse the piece and cut the other half.

6. Do not rip pieces having rough or uneven edges, and never attempt to rip or crosscut without using the fences.

94. A band saw consists of an endless flexible saw blade which runs over two wheels, one directly above the other. These, in turn, are fastened to shafts which, on the modern saw, run in ball bearings. The rims of the wheels, which are generally made of cast iron, are covered with heavy rubber bands cemented to them. The whole is supported and mounted on a cast-iron frame. (Fig. 102.)

The lower wheel is not adjustable, but the upper wheel can be moved vertically and tilted forward or backward. The vertical move-

ment is principally for the purpose of giving tension to the saw, but it also permits the use of saws which have become shorter through breaking and resoldering.

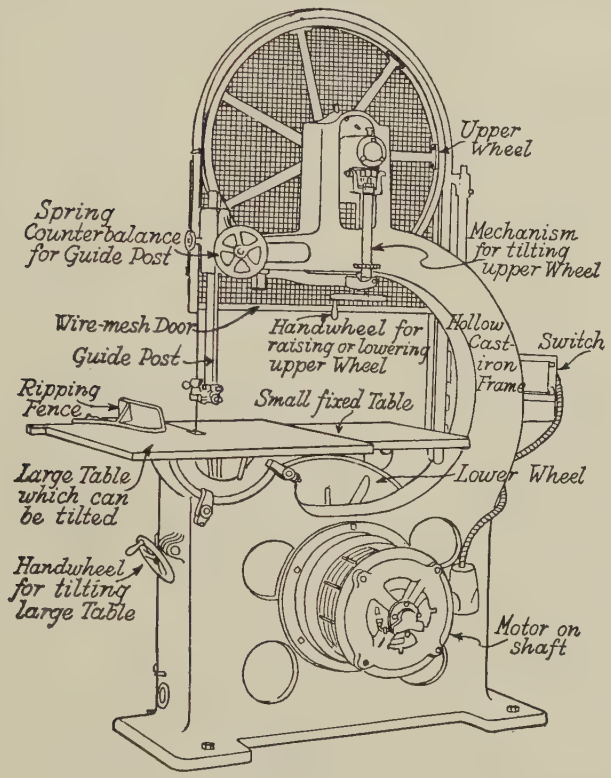


Fig. 102. Band saw

The tilting movement is for the purpose of "tracking" the saw; i.e., making it run on a certain part of the rim of the wheels.

The table of a band saw is in two parts. The larger part, through which the saw runs can be tilted 45 deg. to the right side and 10 deg. to the left side. The smaller part, which is called the "auxiliary table," is stationary.

Two guides are used for the saw blades, one above the table and one below the table. The upper one is fastened to a guide post, which is a heavy square steel rod sliding in a bearing on the column of the casting. It is counterbalanced by a spring, so that it can be moved up or down easily, and adjusted according to the thickness of the stock to be sawed.

The guides consist of two iron blocks faced with four steel jaws between which the saw runs. The size of the opening between the jaws or side guides is adjusted by means of a screw. A small solid steel wheel

runs in a bearing in the guide, and can be moved back or forth, according to the width of the saw blade used. The back of the saw should just clear this wheel when it is running free, but bear against it and cause it to spin around when the wood is being sawed. The wheel should be so adjusted that the teeth of the saw just clear the edges of the jaws.

The lower wheel of the band saw is generally guarded with an iron or wooden door and the upper wheel with a wire-mesh door. The part of the saw between the table and upper wheel is guarded at the column with a grooved block of wood, in which the saw runs, and at the front with a metal and wood guard, which is fastened to the guide post and is raised or lowered with this. The band saw is, therefore, not nearly so dangerous as the circular saw.

Band saws are driven by individual motors connected by belts, silent chains, gears, or couplings, to the lower wheel shaft. In the latest type, the motor is built directly on this shaft, which makes 600 r.p.m. Some saws even make 750 and 900 r.p.m. The sizes of band saws are given according to the diameter of the wheels, such as 42 in., 38 in., 36 in., 30 in., 18 in., etc. They are usually right-hand; i.e., the cutting is done to the right of the operator, but they are also made left-hand if so desired.

If it is found that the teeth point up instead of down when putting a band saw on the wheels, turn the saw blade inside out and this difficulty will be overcome.

Ripping fences for straight cutting or resawing may be purchased for band saws, but are not very satisfactory as the saw always has a tendency to "run off." When it is desired to resaw a board or plank, the best way is to cut in from each edge with the circular saw, as deeply as it will go, and then cut the material left in the middle on the band saw. The kerfs made by the circular saw act as guides for the band saw.

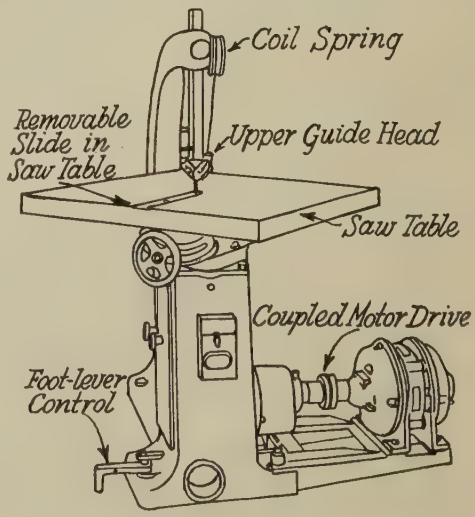


Fig. 103. Jig saw

Band-saw blades are made in different widths from ⅛ in. up. The teeth are of the ripsaw type, and vary in size according to the number of points per inch.

Band saws are made either plain or bevel back; bevel-back saws

are thinner at the back than the front. This feature gives them more clearance, which is particularly valuable in fine scroll sawing. It follows that the narrower a saw, the smaller a curve can be cut with it.

95. A jig saw (Fig. 103) is a machine tool used for all kinds of interior or exterior scrollwork or fretwork. It has a very narrow saw blade, which, unlike the band saw, has a reciprocating movement. The saw blade is supported by an upper and lower guide head, in which it is quickly and easily inserted and clamped. As the saw cuts on the down stroke, it should be inserted so that the teeth point downward. The upper guide head is counterbalanced by a coil-spring mechanism. It has a vertical adjustment of 10 in., so that saws of different lengths may be used.

The saw table resembles that of a band saw, and can be tilted 30 deg. to both sides. A slide in the table can be removed so that an opening is formed through which cuttings from delicate interior scrollwork may drop. A rotary air blower sends a continuous stream of air over the work. The lines to be followed in sawing are, therefore, never obscured by sawdust.

The power is turned on and off by means of a foot pedal, so that the operator has both hands free with which to guide the work. When the power is turned off, a brake is automatically applied.

The machine is driven by an individual motor, belted or coupled to the countershaft, and giving it a speed of 1200 r.p.m. The modern jig saw is self-contained in one casting. The guide heads of older types of jig saws are supported from the ceiling.

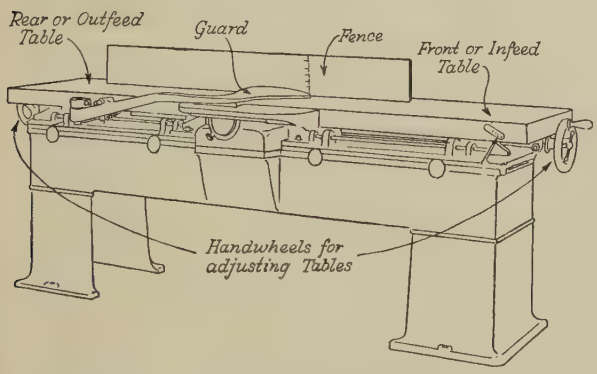


Fig. 104. Large jointer

96. The jointer or hand planer (Fig. 104) is, next to the circular saw, the most necessary and useful machine in the woodworking shop. Its main parts are a heavy cast-iron bed supported on two columns, two tables, and a cutter head mounted on top of the bed.

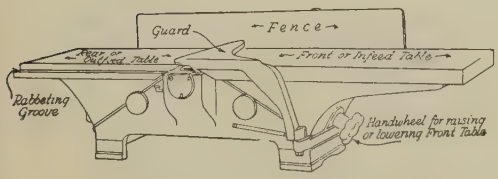


Fig. 104*a*. Bench jointer

The cylindrical shape of the modern cutter head is

a great improvement, as far as safety in operation is concerned, over the old square cutter head. It is mounted on ball bearings, in a special casting which is bolted to the bed near its center, and has either two, three, or four thin knives. The size of the machine is given according to the length of the knives. These run from 4 to 30 in. in length.

The tables are from 1 to 2 in. wider than the knives, and can be lowered or raised by means of handwheels. For all ordinary work, the rear or outfeed table should be level with the knives at their highest point. If the rear table is too high, more will be cut off the front part of a board than at the rear, and as the board is passed over the cutter head, its front end will be seen gradually to rise from the surface of the rear table. If the rear table is too low, on the other hand, the board will drop down on the rear table when its end leaves the front table, causing the cutter head to dig into it.

97. Directions for adjusting the tables. The rear table may be adjusted to the correct height if the directions given below are followed. This adjustment is usually only made by experienced workmen.

1. Take a piece of wood, preferably with a straight edge, and run this edge over the jointer until it projects about 1 or 2 in. over the rear table.

2. Hold the piece in this position, and have someone turn the handwheel on the rear table until its surface just touches the piece of wood.

3. Finish planing the edge of the piece. Watch and see if its surface is in contact with the rear table at all times, and examine the last part of the edge to be pushed over the cutter head to make sure it is absolutely flat.

4. Once the rear table is correctly adjusted, it is recommended to remove the handwheel.

Some jointers have a device which tilts the tables sideways so that "draft" can be planed on straight pieces.

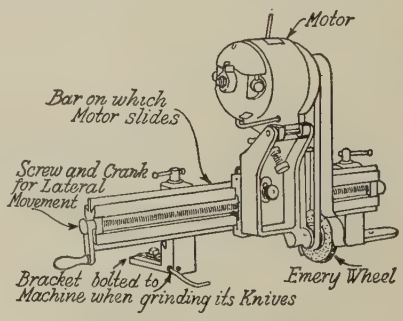


Fig. 105 Knife-grinding attachment

The tables may be pulled away from the cylinder for the purpose of changing or sharpening the knives.

A knife-grinding and setting attachment (Fig. 105), consisting of a small, motor-driven emery wheel, which can be moved back and forth over the knives, may be clamped to the table. This eliminates the work of removing the knives from the cutter head every time they need sharpening.

A fence, somewhat similar to the ripping fence of a circular saw, is clamped to the rear table, and may be moved across its entire width. It may also be tilted to any angle between 45 and 90 deg.

An aluminum guard, which is held by a spring over the part of the knives not in contact with the wood being planed, is furnished with the machine.

Jointers take the place of the hand plane, and are particularly useful in straightening the surfaces of warped boards or planks, jointing edges of boards to be glued, rabbeting, squaring surfaces, and all straight planing in general.

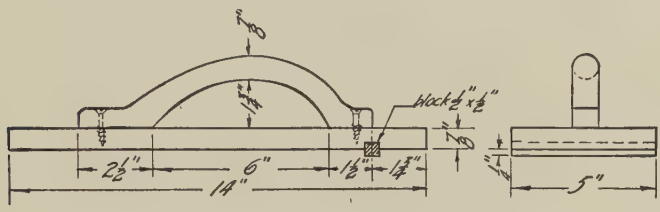


Fig. 106. Pusher for jointer

Pieces less than 12 in. in length should not be planed on the jointer. Thin pieces, such as the blade of a T square, may be planed on the jointer if a heavy piece of the same width is placed on top of it. A thin crosspiece fastened near the end of the heavy piece will serve to push the thin stock ahead. A pusher, as shown in Figure 106, should be made and placed conveniently near the jointer.

Bench jointers, or small hand planes, are very popular and efficient on small pieces. (Fig. 104.)

98. The planer or surfacer (Fig. 107) is a machine which planes boards or planks smooth and to an even thickness. Double surfacers have two cutter heads, and plane both surfaces of a board at the same time, while single surfacers have only one cutter head and can plane only one surface at a time. Planers are made in widths of 20, 24, 30, and 36 in. and usually can take stock from 6 to 8 in. in thickness.

A single surfacer consists of the following main parts: a casting, between the sides of which a heavy table or bed can be raised or lowered, a cutter head mounted over the table, and four feed rolls driven by gears and belts.

The operation of a planer is briefly as follows:

1. The bed is raised or lowered, by means of a handwheel, to from $\frac{1}{16}$ to $\frac{1}{8}$ in. less than the greatest thickness of the stock to be planed. A pointer attached to the bed and a scale fastened to the main casting serve to indicate this measurement.

One surface of a warped board should first be planed straight, or out of "wind," on the jointer before planing it to thickness, as it otherwise will continue to be in "wind." The planed side should be placed "down"; i.e., in contact with the bed.

When planing a rough board, always place the smoothest side down, run it through the planer, and then reverse.

2. Start the machine, and let it gather speed. Set the feed to the speed desired, ordinarily from 14 to 31 ft. per minute, and pull the lever

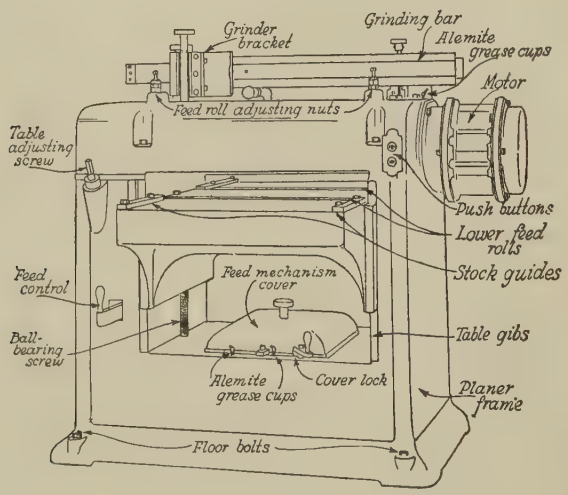


Fig. 107. Planer

starting the feed rolls. The feeding power is transmitted from the cutter head to a shaft by means of a belt. This shaft, in turn, is connected with a train of gears to the four feed rolls. The feeding mechanism can, therefore, be instantly stopped or started independently of the cutter head.

3. Push the board or plank into the machine. It is first gripped by the sectional feed roll on its upper side and a smooth steel roll mounted on the bed directly below this.

The sectional feed roll (Fig. 108) consists of a cylinder, on which a series of wheels with corrugated edges are mounted. They yield as much as ⅜ in. independently of each other. This is to allow for unevenness in the thickness of the stock being planed. This sectional feed roll is held down on the stock by means of heavy weights or springs.

4. The feed roll now carries the stock along without further pushing. It next comes in contact with the chip breaker, which is a heavy

sectional bar, also held down on the stock by means of an adjustable weight. It is placed immediately before the cutter heads, and can be swung out of the way without coming in contact with the knives. It holds the stock firmly to the bed and prevents chips from tearing its surface. (Fig. 109.)

5. The cutter head is of the same type as the ones used on jointers. It is driven either by a motor on shaft, or a motor coupled or belted to the cylinder. It revolves in the opposite direction to the movement of

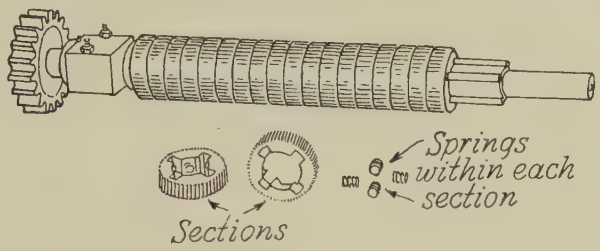


Fig. 108. Sectional feed roll

the stock at a speed of from 3600 to 4000 r.p.m. The knives can be sharpened in the same manner and with the same attachment as that described above for jointer knives.

6. After passing the cutter head, which planes the upper surface of the board or plank, it comes in contact with the back pressure bar, which, like the chip breaker, serves to hold the stock down tightly to the bed so as to prevent chattering. This bar is held down by a spring, the pressure of which can be regulated by a screw.

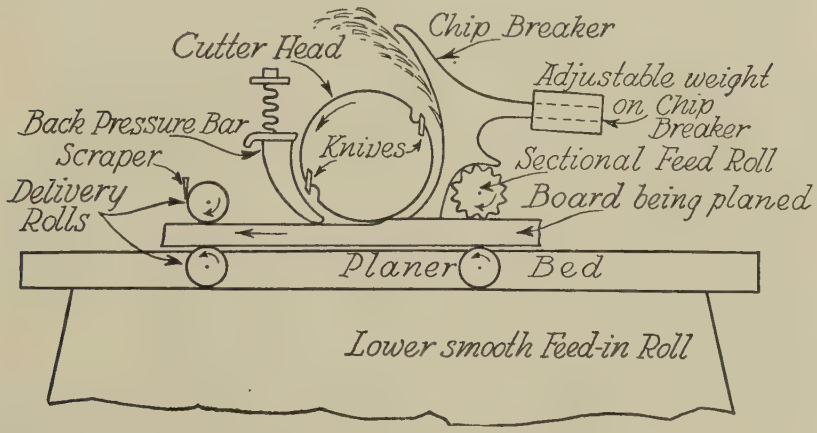


Fig. 109. Sectional view of planer

7. Directly behind the back pressure bar are the delivery rolls, which are smooth steel rolls carrying the stock away from the cylin-

der. One is mounted in the bed below the stock and the other one above the stock. The upper one is held down by adjustable springs, and has a scraper which keeps it free from shavings. (Fig. 109.)

The person operating a planer should stand a little to one side to avoid the danger of being hurt by chips, which occasionally may be thrown back with great violence. For the same reason, pieces shorter than the distance between the feed and delivery rolls should not be planed on the surfacer.

It is often necessary to run stock several times through the machine to reduce it to the desired thickness. When several pieces are to be planed to the same thickness, run the thickest ones through first, then raise the table, and run them all through with the same setting. Raise the table again, if necessary, and repeat.

99. **Mortising machines** are of various kinds: vertical, horizontal, chain mortisers, and hollow-chisel mortisers. Of these, the most popular type is the vertical hollow-chisel mortiser, Figure 110.

This machine consists of a hollow, cast-iron column, on which a horizontal table is mounted about midway, and the mortising head or ram at its extreme upper end.

The mortising head in belt-driven machines, Figure 111, carries the bit spindle, which is mounted in two self-oiling bearings. A long pulley, 4 by 8 in., is fastened to this spindle between the two bearings. The lower end of the spindle carries a chuck, in which the ends of the bits are held by means of a set-screw. The bits have a flattened side, which should butt up against the end of the screw.

Directly below this chuck is a similar chuck mounted on the mortising head independently of the

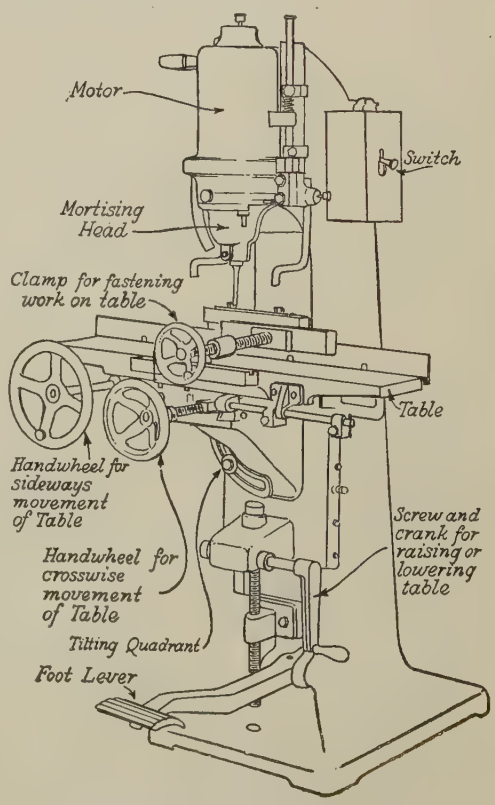


Fig. 110. Hollow-chisel mortiser

spindle. This lower chuck holds the square hollow chisels, inside of which the bits revolve. When putting a bit in the machine, fasten the hollow chisel first, and then insert the bit from below and fasten it in the spindle chuck. A little clearance should be allowed at the end of the chisel so that the bit revolves freely, without overheating.

In a newer type, the mortising head consists of a ball-bearing self-contained motor. (Fig. 110.) The end of the armature carries the bit chuck, while the chuck for the hollow chisels is held in the motor casting.

The mortising head is moved downward by means of a foot lever. When this is released, a spring causes it to return to its first position. Some mortising machines are equipped with an adjustable power feed to give various numbers of strokes per minute. A blower keeps the work free from shavings and cools the chisel and bit.

The table can be moved up or down on the column to allow for work of different dimensions. It has a crosswise movement for centering the stock to be mortised directly under the chisel, and a clamp for holding it firmly in place. It also has a sidewise movement for making successive cuts to complete a mortise. For example, if a ½-in. mortise 3 in. long has to be made, the mortising head must be moved down 7 or 8 times, while the table is moved a little sideways between each cut or stroke.

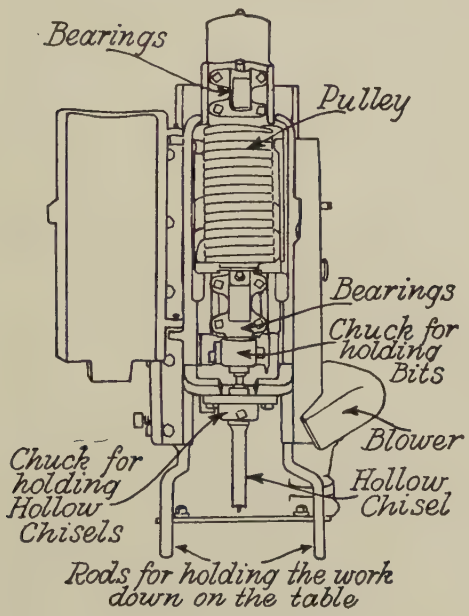


Fig. 111. Mortising head

When a number of pieces have to be mortised alike, the sidewise movement of the table may be controlled by iron rods and stops. The table is also adjustable for oblique mortising. Two bent iron bars fastened to the column can be adjusted so that they hold the work firmly against the table, thus preventing the tendency to climb up when the chisel is withdrawn.

Mortising machines are driven either by belts or by an individual motor mounted on a bracket and belted to the spindle pulley, or by a ball-bearing motor-on-arbor. This latter type eliminates all pulleys and belts. The speed of the spindle should be about 3600 r.p.m.

When a circular saw has a mortising attachment, the chisel is stationary and the table is moved against it. (Fig. 101.) Hollow-chisel

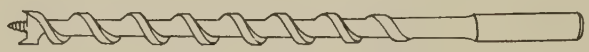


Fig. 112. Machine boring bit

mortisers can be used as boring machines and furnished with chucks holding machine bits. (Fig. 112.)

Chain mortisers differ from hollow-chisel mortisers in that they cut with a small endless chain, the links of which are shaped like saw teeth. They make a mortise with rounded inside corners.

100. The shaper is a machine used for rabbeting, grooving, fluting, beading, and shaping all kinds of moldings. It consists of a casting,

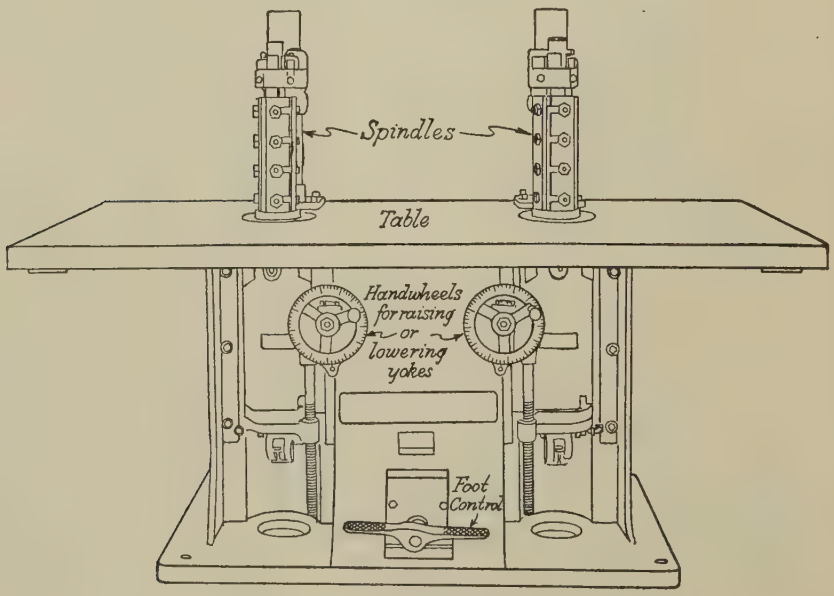


Fig. 113. Double-spindle shaper

which supports a horizontal table through which one or two vertical spindles project. (Fig. 113.) Each spindle is mounted in a casting or yoke, which can be raised or lowered by means of a screw and handwheel. It runs in two ball bearings, one on each side of the pulley. Its upper end is fitted with large and small collars, having V-shaped

grooves cut in their flat sides. The cutting knives are placed between two collars so that their ends fit into the grooves. A nut on the end of the spindle bears against the collars, and locks the knives in place.

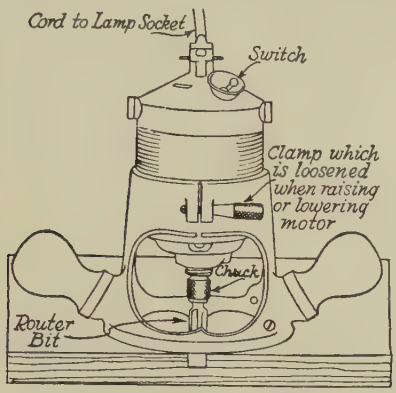


Fig. 114. Portable router

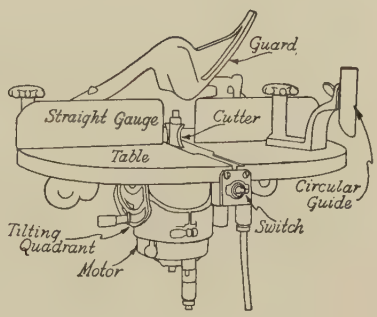


Fig. 115. Portable shaper

The spindle revolves at a speed of from 3600 to 7200 r.p.m. Due to this high rate of speed, the knives cut just as smoothly against the grain as with the grain. This eliminates the reversing mechanism necessary in the older types of single-spindle shapers. The machine may be run by an individual motor belted to the spindle pulley, or by a motor-on-spindle drive eliminating all belts and pulleys.

The shaper is an extremely dangerous machine to use. Various types of guards, which can be screwed to the table, are furnished with the machine.

101. Portable shapers and routers have small motors of from ¼ to 1 horse power each. (Figs. 114 and 115.) They are extremely useful and convenient machines, besides being comparatively safe to operate. Each machine can be furnished

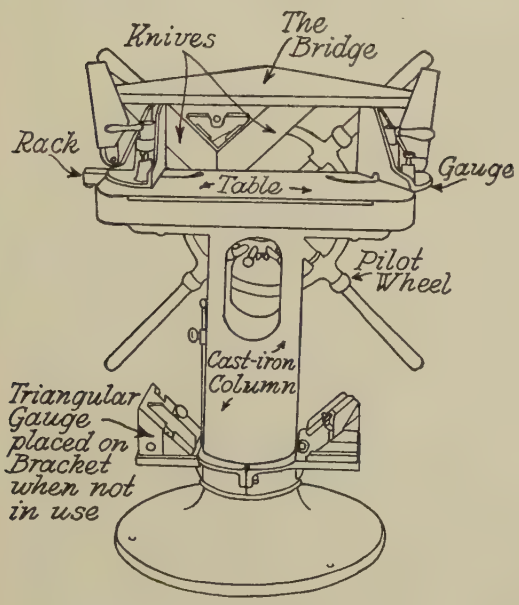


Fig. 116. Wood trimmer

with a number of cutters, bits, and attachments for doing a great variety of work. A list of the jobs that can be done successfully with these machines would be too lengthy. It is, therefore, necessary to name only some of the most important: routing out dadoes and grooves; cutting recesses for hinges; inlaying and veining; reeding and fluting turned columns; shaping edges of table tops, moldings, beads, etc.

102. **The wood trimmer**, although not power driven, is essentially a machine tool. It is particularly useful in the pattern and cabinet shop for cutting all kinds of angles, mitering moldings, and for segment work.

It is composed of the following main parts: a table mounted on a cast-iron column, and two knives which are moved from side to side by a pilot wheel geared to a rack. (Fig. 116.) Two gauges, which can be adjusted to any angle between 30 and 135 deg., are fastened to each end of the table. They can be set instantly and accurately to the principal angles as 30, 45, 60, 90 deg., etc., by means of a tapered pin which fits into corresponding holes drilled in the table. (Fig. 117.) A segment scale for circles from 6 to 72 in. in diameter is also engraved on the table of the larger machines. (Fig. 118.)

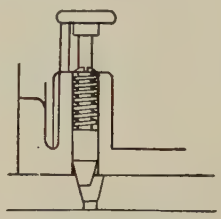


Fig. 117. Tapered pin fitting into table

The knives are ground only on one side, and it is extremely important, when regrinding them, to keep the other side absolutely flat, as they otherwise have a tendency to work away from the stock. They are

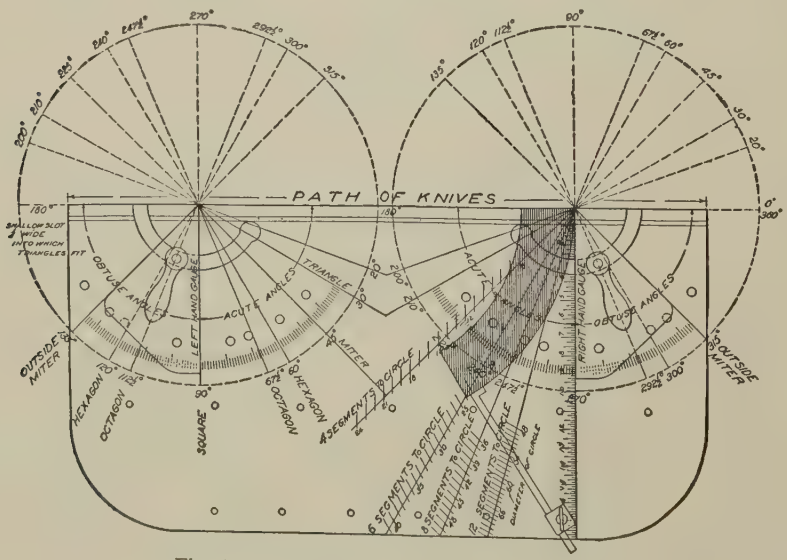


Fig. 118. Graduation of wood-trimmer table

bolted to a casting, the upper part of which slides in another casting, called the "bridge," which in turn is bolted to the main frame. The lower part of the casting carrying the knives is fastened to a rack which is moved by a pinion on the pilot wheel.

A triangular gauge, placed against one of the other gauges, is useful in trimming the sides of the half-lap joints.

Sanding machines are made in several different forms. The most common are belt, disk, spindle, drum, and portable sanders.

103. A belt sander (Fig. 119) generally has two cast-iron columns,

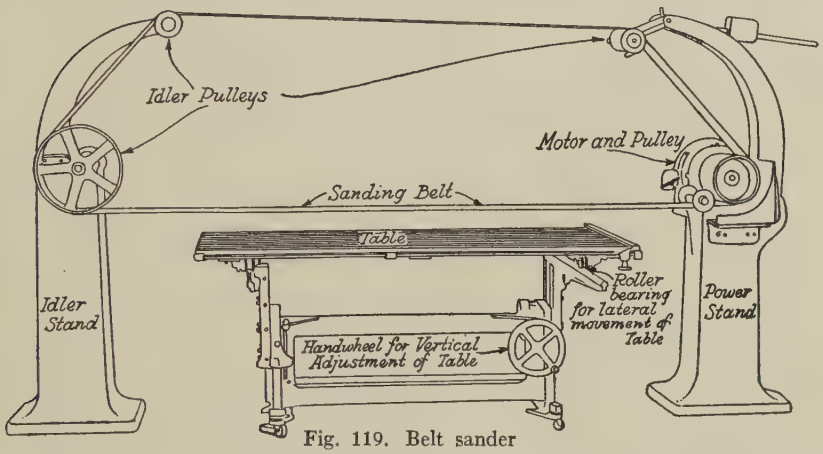


Fig. 119. Belt sander

each of which carries a large pulley and a table placed between these. A motor driving the pulley is mounted on one of the posts. This post is, therefore, called the "power stand." The other post is called the "idler stand." On some machines the two pulleys, including the motor, are adjustable vertically as much as 48 in., and are moved in unison by means of a screw, bevel gears, connecting shaft, and handwheel. The idler pulley also has a horizontal adjustment to provide for tightening the belt. The pulleys on the machine illustrated run in ball bearings, are rubber faced, measure 24 in. in diameter, have a 10-in. face, and a speed of 600 r.p.m.

The table, 32 by 96 in., is built up of wooden strips set 1 in. apart to allow the dust to fall through. It has a horizontal movement of 36 in.

The work to be sanded is placed on the table, and the pulleys carrying the sanding belt are adjusted to the right height. The belt is made of canvas to which the abrasive has been applied. It is known as garnet cloth and is sold by the roll.

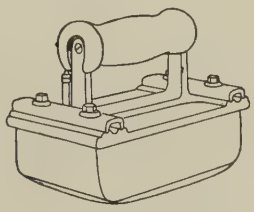


Fig. 120. Pneumatic sanding pad

A pneumatic sanding pad (Fig. 120) which

can be inflated to conform to flat, convex, or concave work, should be used to press the belt down to the work being sanded.

104. **Disk sanders** consist of a steel disk mounted vertically on a cast-iron column. A table is attached to a bracket in front of the disk. It is usually adjustable vertically, and tilts to both sides. It is also

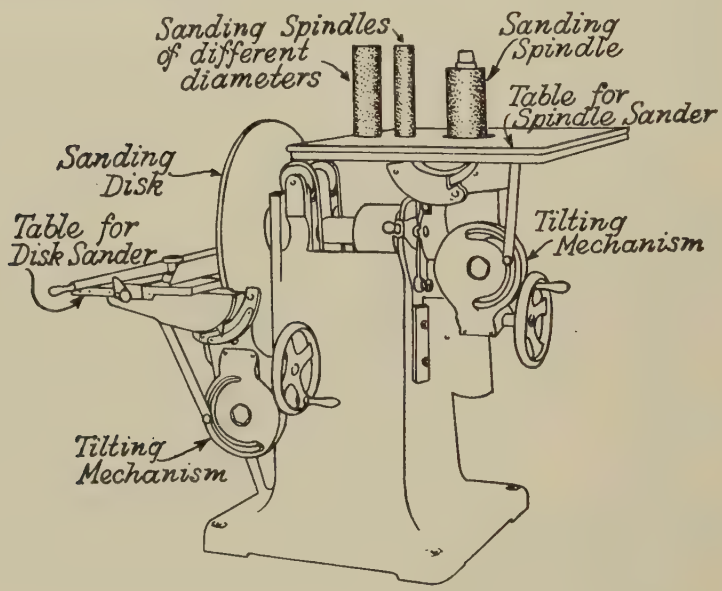


Fig. 121. Spindle and disk sander

equipped with various fences, gauges, and attachments similar to those of a circular saw. (Fig. 121.)

105. **The spindle sander** is composed of a vertical spindle projecting through a horizontal table, which is supported on a cast-iron column. Steel rolls of different diameters can be fastened to the end of the spindle, which revolves at a speed of about 1700 r.p.m. and has an oscillating up-and-down movement. The table may be tilted to various angles. It may be driven by belts or by a self-contained ball-bearing motor.

Disk and spindle sanders are often combined into one machine. (Fig. 121.) The sandpaper is applied to the disk and the rolls with a special cement.

106. **Drum sanders** are large production machines which work on the same principle as planers. They have three or more drums covered with sandpaper of various degrees of fineness, and several rollers which carry the work through the machines.

107. **Portable sanders** are either of the drum or belt type. They

are very efficient and convenient, both for sanding floors and cabinet-work. They are adjustable both to coarse and very fine cutting. (Fig. 122.)

108. **Sharpening machines** are saw-filing machines, saw-setting machines, grindstones, emery grinders, and automatic knife grinders.

Of these, the first three have been discussed in connection with the directions given for sharpening saws and plane irons in Chapter III.

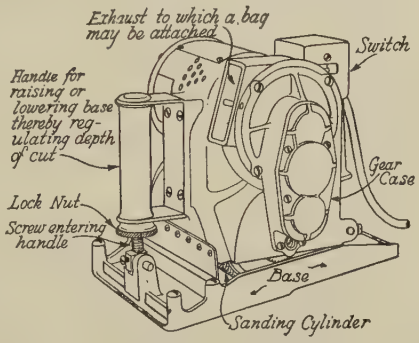


Fig. 122. Portable sander

Emery grinders vary in design and construction all the way from the single hand-driven emery wheel to the ball-bearing, motor-driven, oilstone grinder shown in Figure 123. A machine of this type usually has two emery wheels, one coarse for rapid grinding and one fine for whetting. The wheels are often cup-shaped, being about 8 in. in diameter and having a 2-in. face. The oil drips on the inside of the cup wheels, saturating them, and a wiper prevents the oil from being thrown off the wheels. These wheels run at a speed of 300 r.p.m.

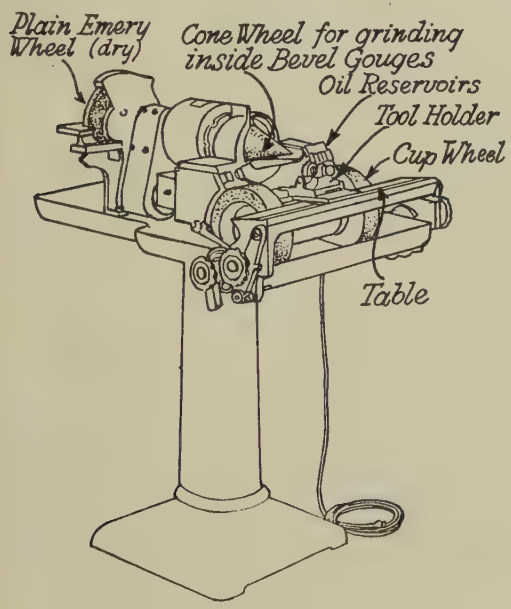


Fig. 123. Oilstone grinder

Besides these wheels, the machine carries a dry emery wheel, an emery cone for grinding gouges and a leather stropping wheel.

The latter three wheels run at a speed of 1800 r.p.m.

The machine carries a table which can be tilted to different angles, and a tool holder for chisels, plane irons, and similar cutting tools. The tool holder has a screw feed mechanism. Gears and wheels are fully guarded.

109. **Automatic knife grinders** are similar to oilstone grinders, but have a table which automatically slides back and forth at right angles

to the cutting wheels. With the new knife-grinding attachments on jointers and planers, these machines are not so indispensable for ordinary woodworking machinery.

REVIEW QUESTIONS

1. What are the advantages of the direct motor drive over the belt drive?
2. What is the purpose of a countershaft?
3. How is power transmitted from a countershaft?
4. What type of work is usually done on a swing cut-off saw?
5. How is the depth of cut adjusted on a hanging swing cut-off saw?
6. Toward which side must the nut on the saw arbor of a circular saw be turned when loosening it?
7. When should the miter cut-off gauge be used in preference to the universal gauge for crosscutting?
8. When is the ripping fence used together with the miter gauge?
9. What is the purpose of the small iron block which may be screwed to the ripping fence?
10. What is the difference between a dado head and a grooving head?
11. Why is it dangerous to use a circular-saw blade which has not been properly sharpened or set?
12. What is a spreader, and for what is it used?
13. How far should a circular-saw blade project over the lumber being cut, and why?
14. Why should the edge of a board placed against the ripping fence always be straight?
15. What is understood by "tracking" a band saw, and how is it done?
16. How should a band saw run with reference to the jaws of the guides and the guide wheels?
17. By what means may the power be transmitted to a band saw?
18. What is understood by a 36-in. band saw?
19. What is the advantage of "bevel-back" band-saw blades over plain band-saw blades?
20. What kind of sawing may be done on a jig saw that cannot be done with a narrow band-saw blade?
21. How does the movement of a jig saw differ from that of a band saw?
22. How is the rear table of a jointer adjusted with reference to the knives?
23. How can you tell if the rear table is too low, or too high?
24. How may the rear table be correctly adjusted?
25. How may thin wood be safely planed on the jointer?
26. What is a pusher?
27. What are the two most common planing jobs done on the jointer?
28. How is a planer adjusted to any required dimension?
29. How much may be taken off at one cut?
30. How should warped boards be planed to thickness?
31. What is understood by the "feeding mechanism," and how is it controlled?
32. What is the advantage of the sectional feed roll over the solid feed roll?
33. How may the knives of jointers and planers be sharpened?
34. How does the cutter head revolve with reference to the direction in which the board is moving?
35. How many smooth steel rolls are there in a single planer, and where are they located?
36. What is the smallest length of board that may safely be planed?

37. What do the chip breaker and the back pressure bar do?
38. How are the chisel and bit of a hollow-chisel mortiser fastened in the machine?
39. How is the table of a vertical hollow-chisel mortiser adjusted, so that the mortise is cut to the required depth and within the gauge lines marked on the board?
40. What is the shape of a mortise cut on a chain mortiser?
41. For what is a shaper used?
42. How are the knives fastened to the spindle?
43. What types of work may be done with portable shapers and routers?
44. For what is the wood trimmer used?
45. How should trimmer knives be ground? Why?
46. What are the most common types of sanding machines?
47. How may the sanding belt on a belt sander be tightened?
48. What kind of oil is used on an oilstone grinder to cool the tools? How is it applied to the wheels?
49. What is understood by a "cup wheel"?
50. How do automatic knife grinders differ from oilstone grinders?

Nearly all broad-leaved trees possess the power to reproduce themselves by growing new shoots from old roots, known as "sprouting." (See p. 229.)

Virgin stand of beech, Pisgah National Forest, North Carolina.
(Courtesy U. S. Forest Service.)

CHAPTER III

THE SHARPENING OF TOOLS

The ability to sharpen tools properly is the first requisite of anyone aspiring to become a woodworker. It always pays *to take the time to sharpen tools, both from the standpoint of performance, as well as actual time saved in the execution of the work.*

SHARPENING RIPSAWS AND CROSSCUT SAWS

111. Jointing Saws. Jointing is necessary only when the teeth of a saw have been worn uneven by hard usage, or damaged through carelessness or accident.

1. To joint a saw, clamp it in a saw vise, and run a flat file over the teeth until every tooth is touched by the file. (Fig. 124.) The points of some of the teeth will now be quite flat, while others will barely be touched by the file. The best results are obtained if the file is fastened in a holder made especially for the purpose.

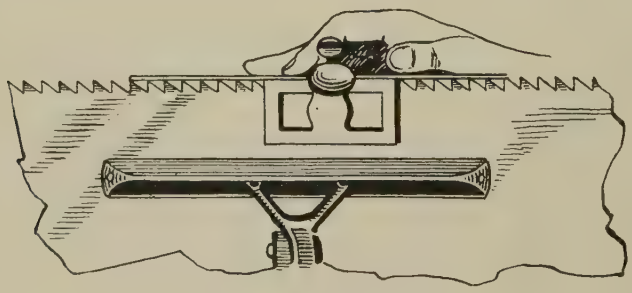


Fig. 124. Jointing a saw

2. If the teeth are of uniform height, they are filed until they are of the same size and shape. To do that, start the file which should be a 7-in. slim taper, triangular file, in the gullet of the teeth, and file down into the blade, until the tooth to the right is up to a point, and half of the flat point of the tooth to the left has been removed. Start the file in the next gullet to the left, and continue until all the teeth have been filed. The file is held level and at right angles to the blade of the saw, whether the saw is of the rip or crosscut type.

112. Setting Saws. When the teeth of a saw are all even as in a

new saw, they must be bent slightly outward (Fig. 125) so that the saw kerf will be wide enough to prevent the saw from binding in the wood. This operation is called "setting," and requires a special tool called a "saw set." (Fig. 126.)

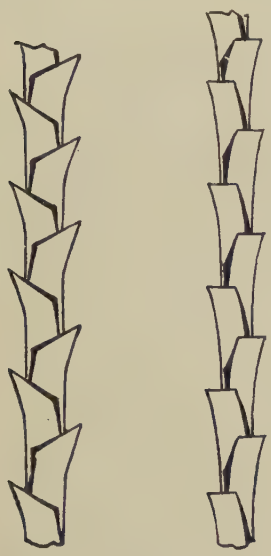


Fig. 125. Crosscut and ripsaw teeth properly set. Bottom view of saws

Fig. 126. Saw set

1. The saw set is adjusted so that the amount of set given the teeth corresponds to the number stamped on the lower edge of the saw blade near the handle.

2. Fasten the saw in the vise, and, starting at one end, bend every other tooth toward you. The teeth should be bent about two thirds from the point to the gullet. Reverse the saw, and set the other half of the teeth in the same way.

113. Filing a Ripsaw. The teeth of a ripsaw are shaped like a series of small chisels, and should be filed straight across. (Fig. 27.)

1. After the saw has been set, place it in a saw vise so that the gullets of the teeth are about ⅛ in. above the jaws of the vise. If a saw vise is not available, the saw may be placed between two pieces of wood in an ordinary bench vise.

2. With the handle of the saw placed to the right, start the file at the point in the first gullet to the left of the first tooth set toward you.

3. Hold the file level and at right angles to the saw blade, and push it straight across the teeth.

4. Repeat the process in every other gullet, until half of the teeth have been filed. Then reverse the saw, placing the handle at the left, and file the other half.

114. Filing a Crosscut Saw. The teeth of a crosscut saw (Fig. 28) are filed to a knife point. The process is the same as described for filing a ripsaw. The file is held level, but at an angle of about 60 deg. to the blade of the saw. In this way a bevel is filed on the front side of one tooth, while at the same time a corresponding bevel is filed on the rear side of the adjoining tooth. (Fig. 127.)

115. To Sharpen a Plane Iron. When a plane iron, gouge, chisel, or spokeshave blade has been nicked, or has been whetted on the oilstone so often that its bevel has become short, it is necessary to grind it on a grindstone or emery wheel. Ordinarily, a cutting iron may be whetted a few times before it is necessary to regrind it.

1. Remove the cap from the cutter iron, and grind the bevel on a grindstone until it is true, straight, and at right angles to the side of the iron. Move the iron back and forth across the face of the stone while grinding, and use plenty of water to prevent burning.

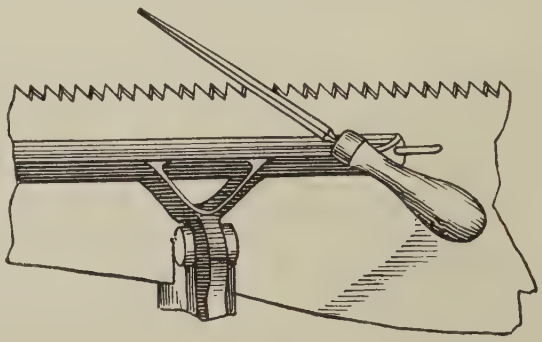


Fig. 127. Filing a crosscut saw

It is important that the bevel is ground flat or slightly concave, and that the iron is not burned while grinding. A device for holding the tools, as shown in Figure 128, is recommended. If an oilstone grinder (Fig. 123) is used, the iron should be cooled by water or kerosene flowing over it. It is extremely difficult to avoid burning the iron on a dry emery wheel or grindstone.

A tool holder, in which the iron is clamped, can be set to different angles, and insures a straight and even bevel.

2. The wire edge formed during the grinding process is now removed by *whetting* the iron on an oilstone. Machine oil thinned with kerosene is used as a lubricant. Place the bevel flat on the oilstone, raise the iron a little and move it back and forth or with a circular motion, pressing on it with the left hand. (Fig. 129.) Use the whole surface of the stone in order to wear it down evenly.

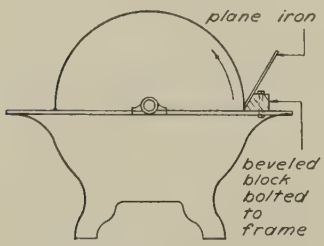


Fig. 128. Old-fashioned grindstone

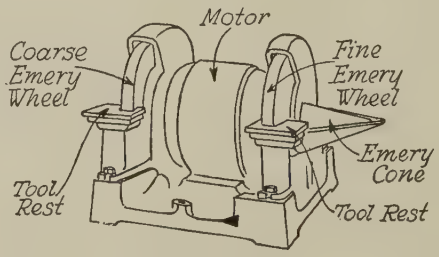


Fig. 128*a*. A modern emery-wheel grinder

3. Reverse the iron, and place it flat on the oilstone with the beveled side up. Press on it with the left hand, and move it back and forth a few times. (Fig. 130.) Be careful to hold it absolutely flat.

4. Repeat the process until the wire edge is removed. Test the

sharpness of the iron on the thumb nail. If the iron is sharp it takes a hold in the nail; if it is not sharp, the nail slides over it. (Fig. 131.)

Chisels and spokeshaves are sharpened in the same way.

Fig. 129. Whetting chisel; first step

A worn-down oilstone can easily and quickly be leveled off by rubbing it on an iron surface, using kerosene and powdered emery as an abrasive.

Fig. 130. Whetting chisel; second step

116. To Sharpen Gouges. (1) Outside bevel gouges are ground on the outside only. Grasp the handle with the right hand, and hold

the blade to the surface of the stone with the left hand. Move the gouge across the face of the stone with a rolling motion.

2. Inside bevel gouges are ground on a conical grinding wheel.

3. Both types of gouges are whetted on an oilstone having a wedge-shaped cross section and rounded edges. (Fig. 141.) Such a stone is called a "slip stone." (See Sharpening of Wood-Turner's Gouge, Art. 120.)

Fig. 131. Testing sharpness of chisel on thumb nail

117. To Sharpen and Adjust a Cabinet Scraper. (1) Grind and whet the cabinet scraper exactly as you would a plane iron. (Art. 115.) It is necessary to regrind the cabinet scraper every time it becomes dull.

2. Place the scraper in a vise, and bend the edge with a burnisher. Start the burnisher in contact with the whole bevel, and move it across

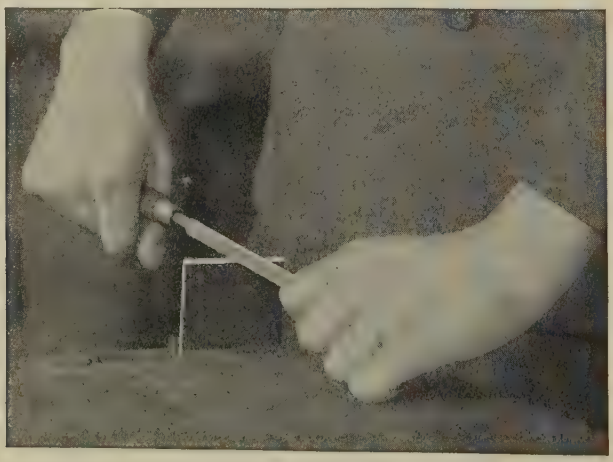


Fig. 132. Bending edge of cabinet scraper with burnisher

the blade, pressing lightly. Elevate the handle of the burnisher gradually in the succeeding strokes until it forms an angle of about 15 deg. with the horizontal, and increase the pressure. (Fig. 132.)

An excellent burnisher can be made from an old triangular file by grinding away the teeth on a grindstone.

3. To adjust the blade in a cabinet scraper, loosen the three thumbscrews in the holder, place it on a flat wooden surface, and insert the blade from the bottom so that the bevel is toward the adjusting thumb screw in the center.

4. Tighten the two thumbscrews which clamp the blade to the holder, and turn the adjusting screw until it bears loosely against the blade. Turn it a fraction of a revolution at a time, until the scraper cuts a shaving of the desired thickness.

118. To Sharpen a Hand Scraper. (1) Fasten the scraper blade in the vise with one of the long edges up.

2. Grasp a triangular file with both hands, one at each end. Hold the file level and at right angles to the blade, and move it back and forth over the edge, longitudinally. (Fig. 133.) This method of using a file is called "draw-filing."

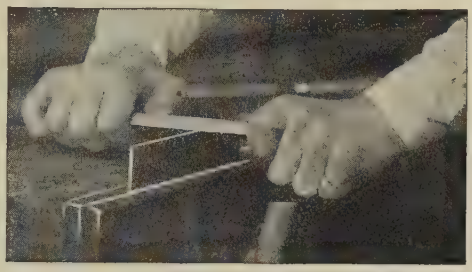


Fig. 133. Draw-filing hand scraper

3. When the two long edges have been drawfiled, the burr formed by the filing must be removed on the oilstone. Hold the scraper perpendicular to the face of the stone, and whet the edge. (Fig. 134.) Then place one side flat on the face of the stone moving it back and forth (Fig. 135), then the other side, and then again the edge until the burr has disappeared.

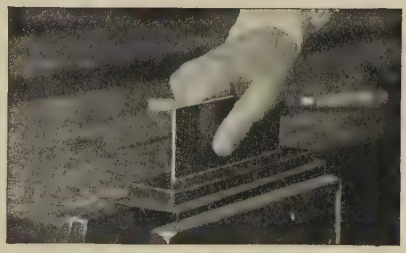


Fig. 134. Whetting edge of hand scraper

4. When both edges have been sharpened, place the scraper in a vise. Turn the edges by moving a burnisher over them, tilting it slightly to alternate sides. (Fig. 136.) The edges also may be turned by placing the scraper on end and moving the burnisher upward, as shown in Figure 137*a*. Still another and easier way is to hold the burnisher flat on the workbench and move the scraper across it, tilting it slightly to alternate sides. (Fig. 137.) To produce an extra-fine edge on a scraper, a drop of oil should be rubbed on the burnisher.

5. To resharpen a hand scraper, place it flat on the bench top, and flatten the turned-up edge with the burnisher. Then repeat the process described in the preceding paragraph.

A hand scraper may be resharpened with the burnisher several times before it needs to be drawfiled.

119. To Sharpen an Auger Bit. (1) To sharpen the nibs, hold the bit against the side of the workbench so that the screw points upward. File the nibs on the *inside* only, with an auger-bit file, until the cutting edge is sharp. (Fig. 138.)

2. To sharpen the lips, rest the screw of the bit on the bench, and file the lips on the *upper* side only. (Fig. 139.) Remove an equal amount of material from both lips.

3. To straighten an auger bit that has been bent, roll it on a flat surface to determine where it has been bent. Strike light blows on the high side with a mallet or hammer until the bend has disappeared.

Fig. 135. Whetting side of hand scraper

SHARPENING TURNING TOOLS

120. The gouge (Fig. 140), which is similar to an ordinary outside bevel gouge, is ground on a sandstone or an emery wheel.

1. The end of the gouge is ground to a semicircular shape, and the bevel should extend well around to the sides so as to leave no sharp corners as on the ordinary gouge. The bevel should be about twice as long as the gouge is thick.

2. Grasp the handle with the right hand, and hold the blade to the surface of the stone with the left hand. Move the gouge across the face of the stone with a rolling motion.

3. When the grinding has been completed, the gouge is whetted on an oilstone. The bevel is brought in contact with the stone, and the gouge moved back and forth, at the same time rolling it from one side to the other.

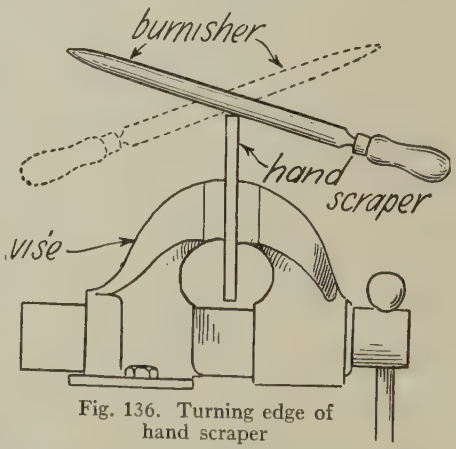


Fig. 136. Turning edge of hand scraper

4. The wire edge, which is bent toward the inside by this process, is removed by rubbing the rounded edge of a slip stone back and forth

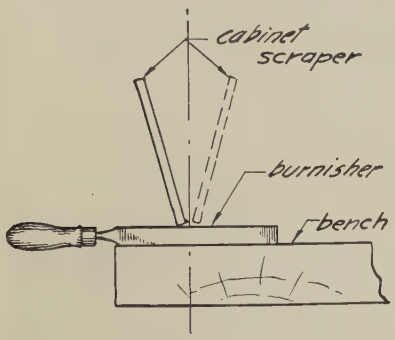


Fig. 137. Turning the edge of a hand scraper

Fig. 137*a*. Another method of turning the edge of a hand scraper

over it. (Fig. 141.) Care should be taken to keep the whole edge of the slip stone in contact with the inside of the gouge during this operation.

121. **The square-nose chisel** is like an ordinary chisel, except that it is longer. (Fig. 140.) In fact, a common chisel, which is fairly heavy and has a long blade, may be used in its place. It is sharpened exactly in the same manner as a common chisel. (Art. 115.)

Fig. 138. Filing nibs on auger bit

122. **The skew chisel** (Fig. 140) is ground so that two bevels are formed instead of one. The cutting edge should be at an angle of about 65 deg. with the side of the chisel. While grinding, grasp the handle firmly with the right hand, press down on the blade with the left, and hold the chisel at such an angle that the cutting edge is parallel to the axis of the grindstone or emery wheel. (Fig. 142.)

Whet the chisel on the oilstone, and test for sharpness on the thumb nail.

123. **The parting or cut-off tool** (Fig. 140) has two bevels, which should be of equal length and meet in the ridge running through the center of the blade. If they do not meet at this point, which is the thickest point on the chisel, it will not cut itself free, but will bind

and stick in the wood. The bevels should be ground straight and true. The wire edge is removed on the oilstone.

Fig. 139. Filing lips on auger bit

124. **The round-nose chisel** (Fig. 140) is ground very much like a gouge. As it has only one bevel, the opposite side is held flat on the oilstone in the same manner as a square-nose chisel.

125. **The diamond-point or spear-point chisel** (Fig. 140) is like a round-nose chisel except that it is pointed instead of rounded. It has two bevels, both on the same side of the chisel. While grinding, it should be held on the stone at an angle, so that its edge is parallel to the axis of the stone. It is whetted in the same manner as a square-nose and a round-nose chisel.

126. **The right or left skew chisel or turning chisel** is shaped like an ordinary skew chisel, but has only one bevel. It is sharpened like a spear-point chisel. (Fig. 140.)

127. **To Clean a Rasp or a File.** The old accepted method of cleaning files is to use fire, as follows:

1. When a rasp or file has been gummed up with particles of wood wedged between its teeth, it may be cleaned by dipping it in alcohol and setting fire to it. Hold the file by the handle, dip it into a bottle, or pour a little alcohol over it carefully. *Cork the bottle,* hold the wet file horizontally, light a match, and apply it to the file. The alcohol will burn with a small blue flame for about half a minute, and then die out.

Solid alcohol may be used instead of liquid alcohol. Hold the file in the flame for short periods at a time.

2. Brush the file with a file card. This usually removes all traces of wood from the file. If the file is not clean after it has been brushed, a second application of alcohol is necessary.

In most cases, however, it is readily possible to clean files in a very satisfactory way by soaking them in hot water for an hour and then

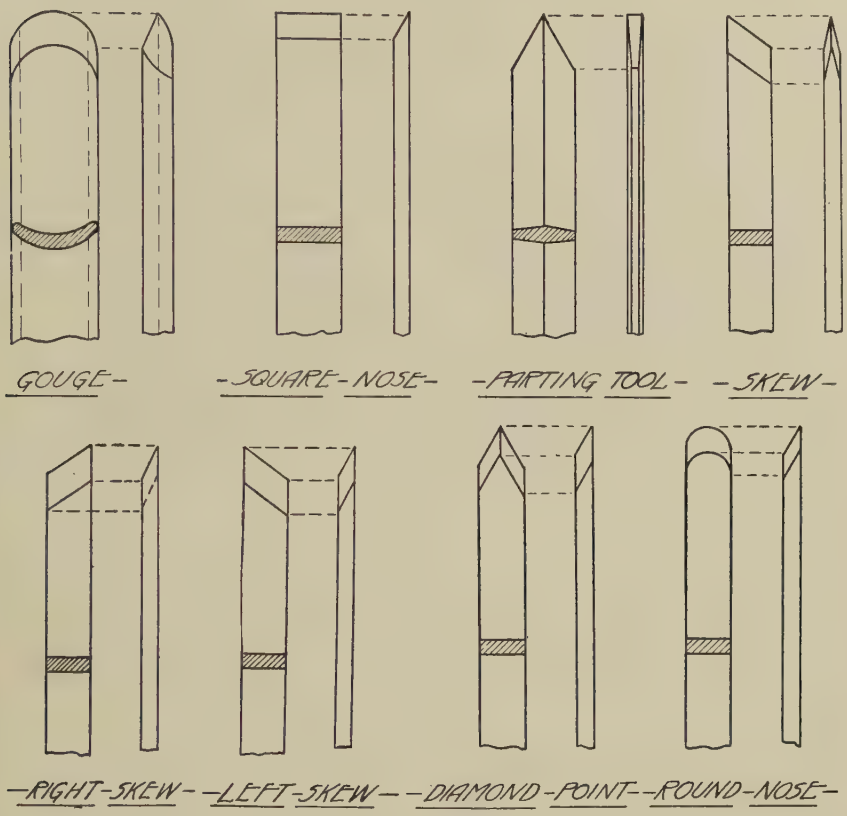


Fig. 140. Turning tools

brushing them with a steel brush. The soaking swells the wood which is stuck between the teeth of the file and loosens it so that it may be readily removed with a brush. It is necessary, however, that files dry quickly to prevent rusting.

SHARPENING CIRCULAR SAWS

128. Jointing Circular Saws. To joint a circular saw, lower it until its teeth barely project above the saw table. They should project just enough to score a piece of wood held flat on the table.

Start the saw, and pass a soft emery stone over the table above it. Raise the saw slightly, and continue until all the teeth have been touched.

129. Filing Circular Saws. Place the saw in an automatic saw-filing vise as shown in Figure 143, or between two boards with semi-circular ends held together by a dowel. (Fig. 144.) These boards,

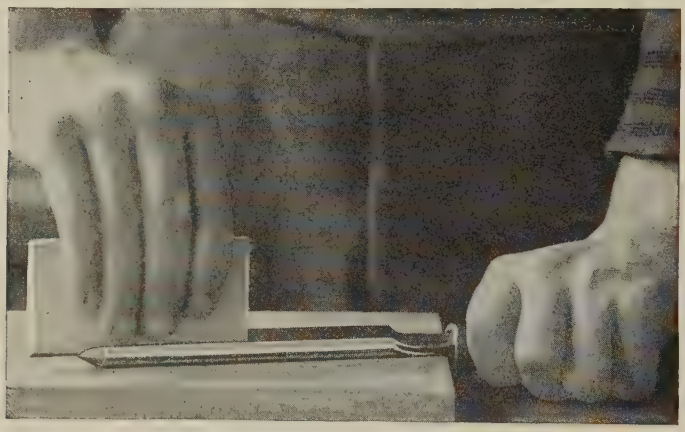


Fig. 141. Whetting inside of gouge with slip stone

with the saw between them are then clamped in a bench vise during the filing process.

1. Adjust the saw-filing vise to a vertical position for a ripsaw, and file the teeth straight across, holding the file in a horizontal position.

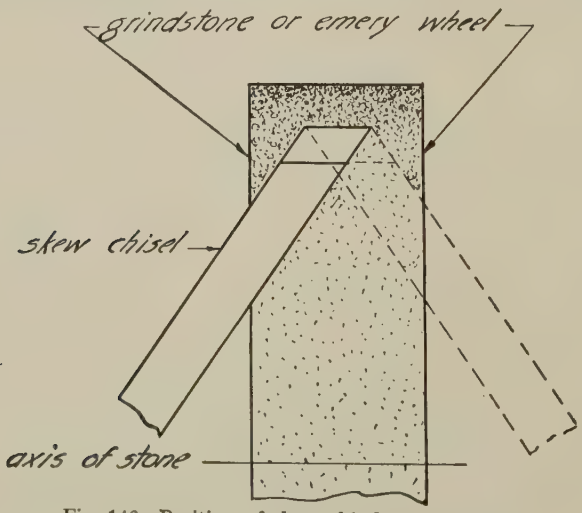


Fig. 142. Position of skew chisel on grindstone

A flat file with a rounded edge is preferred. Some filers give ripsaw teeth a slight bevel on the back.

2. Crosscut saws are set and filed in the same manner, except that bevels are filed on the sides of the teeth of crosscut saws, as explained in Article 114. The bevels should not extend all the way down to the

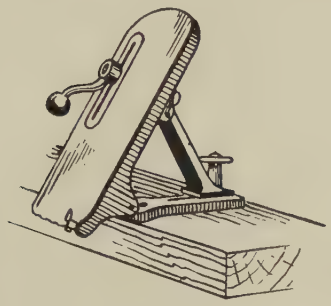


Fig. 143. Saw-filing vise for circular saws

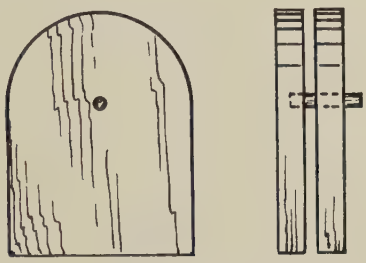


Fig. 144. Boards for holding circular saws while filing

gullets. (Fig. 145.) When filing crosscut saws, the saw-filing vise should be set at an angle.

3. The ripsaw teeth both on miter and dado-head saws (Figs. 98 and 99) should be filed $\frac{1}{16}$ in. lower than the crosscut teeth in order to insure a smooth, clean cut across the grain.

4. It is important to round the bottom of the gullets on all circular saws. Square or sharp gullets cause cracks in the saw at the base of the teeth. (Fig. 146.)

130. Gumming Circular Saws. After repeated filings, the teeth

Fig. 145. Bevels on circular crosscut saws. Wrong shape of bevel and gullet at X

become too short and their gullets must be cut deeper. This is called "gumming," and is done on an emery wheel of the proper shape.

131. Setting Circular Saws. Small circular saws 6 or 8 in. in diameter may be set with an ordinary saw set, but larger saws should be swaged or set by striking the teeth with a hammer. In order to equalize the force of the blow, it is recommended to use an automatic trip hammer. (Fig. 147.)

1. Adjust the trip hammer to the size of the saw. This is centered by a conical nut fitting into the arbor hole. Only about half of a tooth, or less, should project over the anvil of the apparatus.

2. Move the handle which operates the trip hammer, and set every other tooth.

3. Reverse the saw, and set the remaining half of the teeth.

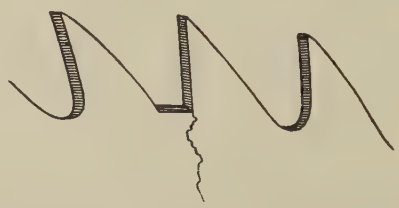


Fig. 146. Crack caused by square gullet on circular ripsaw

4. The saw should now be examined, and the teeth that need it touched up with a file.

When it is not necessary to joint a saw, it is better to set it before filing it.

Miter and dado saws are not set. They are hollow ground; i. e., they are thinner at the center than at the edge. This method of grinding gives them sufficient clearance and produces a smooth cut.

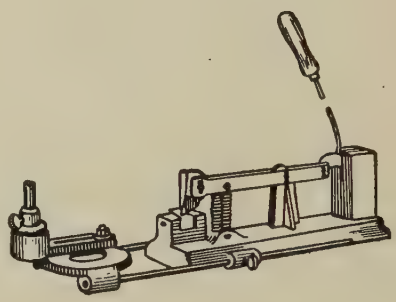


Fig. 147. Trip-hammer saw set

132. Side Filing Circular Saws. After the teeth have been set and filed, they should be side filed so that all the points project the same amount over the sides of the saw. A special tool, called a "side file," should be used for this purpose. An oilstone is used instead of a file on hollow-ground saws.

133. To Braze Band Saws. (1) Straighten out any kinks or bends the saw may have received in breaking, and *scarf* the two ends to be soldered; i.e., file their sides to a taper for a distance equal to the length of one or two teeth. (Fig. 148.) This filing should be done carefully, so that the filed surfaces are perfectly flat and the finished joint is of the same thickness as the rest of the saw.

A band saw should always have an even number of teeth.

2. Clamp the saw in a brazing clamp (Fig. 149) so that it is perfectly aligned. Mix a little borax with water to form a paste, and coat the filed surfaces with this mixture.

This is called a "flux," which keeps the surfaces clean while the heat is applied. A specially prepared flux also may be used.

3. Cut a strip of silver solder the length of the scarf, coat it with the flux, and insert it between the surfaces to be soldered.

Silver solder for band-saw brazing is manufactured in rolls of different widths.

4. Heat a pair of brazing tongs (Fig. 150) until they take a bright-red color, and clamp the joint together. The red-hot tongs heat the

Fig. 148. Scarfing band saws

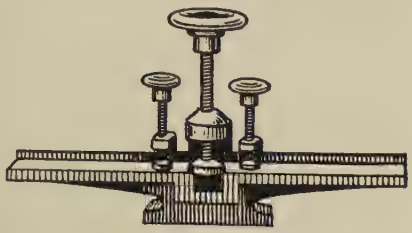


Fig. 149. Brazing clamp

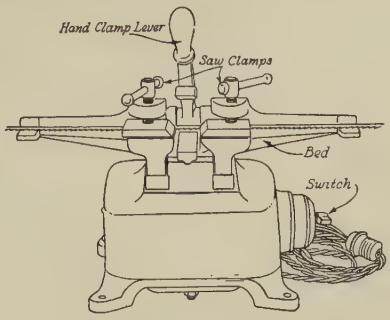


Fig. 149*a*. Electric band-saw brazer

blade and melt the solder. Keep the tongs clamped on the saw blade until they turn black. If the joint is cooled too quickly, it does not hold. The joint also may be heated by a blowtorch, special brazing lamp, or electric current.

Fig. 150. Brazing tongs

When using an electric brazer, Figure 149*a*, the joint should be prepared and clamped as described above. When the current is turned on, heat is automatically applied to both ends of the saw blade. After a few seconds, the joint becomes red and the solder melts. The current is then turned off, and the center clamp is tightened for a few seconds to bring the ends of the joint close together.

5. When the joint has cooled, remove any unevenness with a fine file.

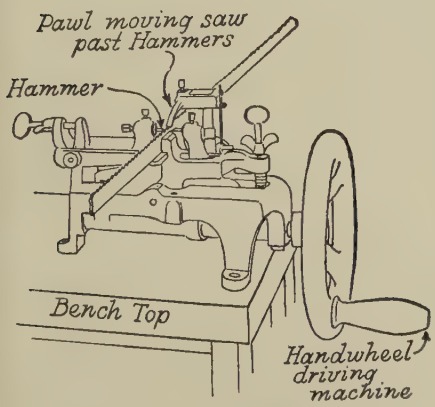


Fig. 151. Band-saw setting machine

SHARPENING BAND SAWS

134. Setting Band Saws. Band saws may be set by hand with an ordinary saw set, or by machine. Band-saw setters are either hand or motor driven. They have two hammers, which automatically bend the teeth to alternate sides, and a pawl, which moves the saw past the hammers. (Fig. 151.) The amount of set and pawl movement or feed is adjustable.

1. To use the setting machine, adjust the amount of set

and the feed. Mark the point, when the setting begins, with the chalk. See that the saw rests on a table and can move freely through the machine.

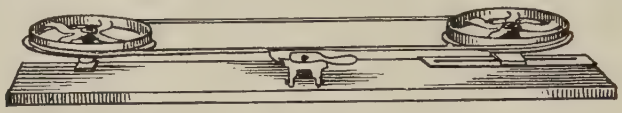


Fig. 152. Band-saw fitting wheels

Fitting wheels (Fig. 152), which are faced with leather, are very convenient for mounting the saw while it is being set or filed.

135. Filing Band Saws. Filing may be done by hand or by machine. Some machines do both the setting and filing operations. When filed by hand, it is very convenient to use a special vise 20 in. long in connection with the fitting wheels. If this is not available, an ordinary bench vise may be used and the saw laid in the trough of the bench.

1. File the band saw straight across in the manner explained for filing hand ripsaws. Use a blunt triangular file with rounded edges.

The machine illustrated in Figure 153 can file practically any kind of saw, rip or crosscut, hand saws, circular saws, and circular or band saw.

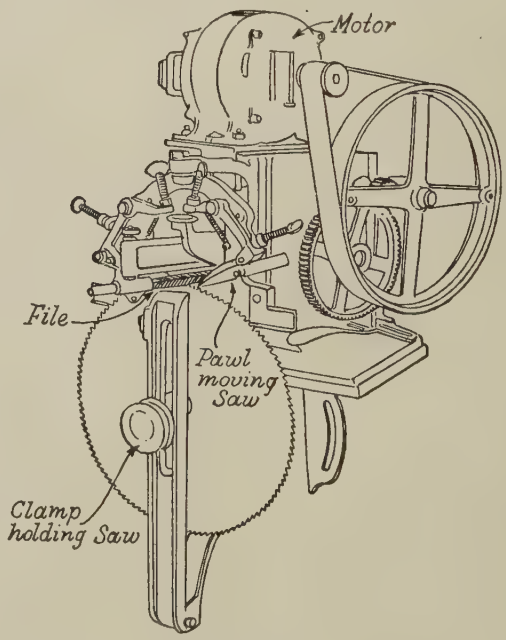


Fig. 153. Universal filing machine

136. To Sharpen Planer or Trimmer Knives. Planer or trimmer knives are ground with only one bevel. Planer or jointer knives may be sharpened without removing them from the cutter head of the machine as explained in Article 97. They also may be sharpened on an automatic knife grinder. Trimmer knives always should be sharpened on the latter.

1. Fasten the knife securely to the carriage of the automatic knife grinder, and adjust it so that the bevel will be ground at the right angle, from 30 to 40 deg., and the same amount of material removed from each end of the knife.

2. It is important that the knives are exactly of the same weight, otherwise the high-speed cutter head will be unbalanced and not run

smoothly. It therefore, is necessary to weigh the knives. A special knife balance is manufactured for this purpose.

3. When the knives have been ground and are of the same weight, they are whetted either on a fine oilstone wheel on the grinding machine, or on an ordinary oilstone rubbed over the edges by hand.

REVIEW QUESTIONS

1. How is a handsaw jointed, and when is this operation necessary?
2. What is the purpose of setting a saw?
3. At what point is the filing of a ripsaw started?
4. Compare the filing of a crosscut saw with that of a ripsaw
5. What is the difference between grinding and whetting?
6. When is it necessary to grind a chisel or a plane iron?
7. Should a grindstone run against the tool or away from it?
8. How is a "wire edge" formed? How is it removed?
9. How may the sharpness of a plane iron or chisel be tested?
10. What type of stone is used for grinding inside bevel gouges?
11. What type of stone is used for whetting gouges?
12. What is a burnisher? For what is it used?
13. What is understood by "draw-filing"?
14. How is a cabinet scraper sharpened?
15. How is a hand scraper sharpened?
16. Why should an auger bit not be filed on the outside of the nibs?
17. Why are the lips filed only on the upper surface?
18. How is a skew chisel held while it is being ground?
19. How are round-nose and diamond-point chisels ground?
20. How may particles of wood wedged between the teeth of a rasp or file be removed?
21. How is a circular saw jointed?
22. How is a circular saw filed and gummed?
23. How is a circular saw set?
24. Why are miter and dado saws not set?
25. How is a band saw "scarfed"?
26. Why should a band saw always have an even number of teeth?
27. What is used as a "flux" when brazing saws? Why should a flux be used?
28. A band saw is set and filed by hand in the same manner as a.....saw.
29. Why should jointer and planer knives be of the same weight?

CHAPTER IV

PLANING AND SQUARING TO DIMENSIONS

Planing and squaring to exact dimensions is the ABC of all good woodwork. It must be thoroughly mastered before any other process can be undertaken successfully.

138. **To Square Small Boards to Dimensions.** (1) Select the best of the two widest sides, and plane it just enough to clean it off and make it perfectly flat. Test this surface with the try-square, holding

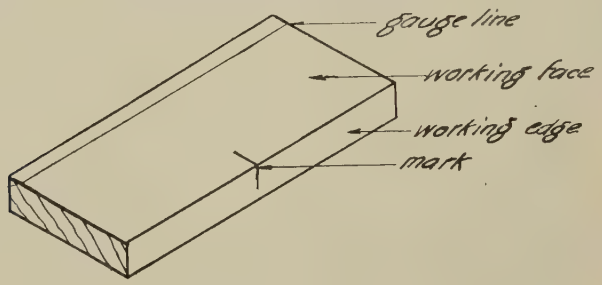


Fig. 154. Squaring board to dimensions. Steps 1 to 3

it lengthwise, crosswise, and diagonally at several points. This surface is called the "working face."

2. Select the best of the two edges, and plane it until the surface is true and square to the working face. This edge is called the "working edge." Mark the working face and working edge with a pencil. (Fig. 154.)

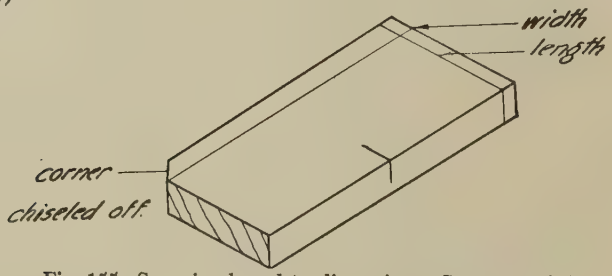


Fig. 155. Squaring board to dimensions. Steps 4 and 5

3. Set a marking gauge to the desired width. With a rule measure the width from the spur of the gauge to the block. Hold the block of the marking gauge against the working edge, and mark a line on the working face, pushing the gauge away from you.

If the width of the board is more than 5 or 6 in., the marking gauge cannot be used. If a panel gauge is not available, measure the width with a ruler at two points, one near each end. Then, draw a pencil line, along a straightedge, through these two points.

4. Chisel off the corner outside the gauge line, and plane the best end square to both working face and working edge.

5. Measure the length of the piece from the end just planed, and square lines all around, using the try-square and a knife or sharp pencil. (Fig. 155.)

6. Saw off the surplus lumber outside this line, using a bench hook, or clamping the piece in the vise. Chisel off the corner as before, and plane this end to the line marked, so that it is square to both the working face and the working edge.

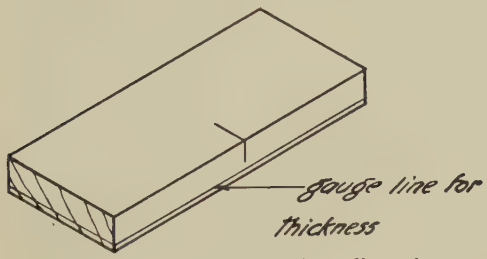


Fig. 156. Squaring board to dimensions. Step 8

7. Plane the edge opposite the working edge to the gauge or pencil line, and square to the working face.

8. Gauge the thickness from the working face on both edges and ends. (Fig. 156.)

9. Plane the last face, opposite the working face, to these gauge lines.

In cases where the board is very narrow or already has the desired

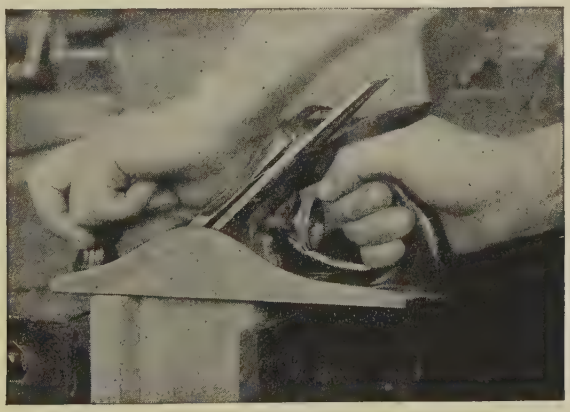


Fig. 157. Planing end of narrow piece of wood

width, splitting of the end wood may be prevented if a piece of wood is placed in the vise behind the edge while planing the ends. (Fig. 157.)

139. To Joint Boards for Gluing. (1) Wide surfaces, such as

table tops, are built up of two or more boards, whose edges are jointed and glued together. After enough boards have been cut to length to form the width, it is a good plan to arrange them so that the best

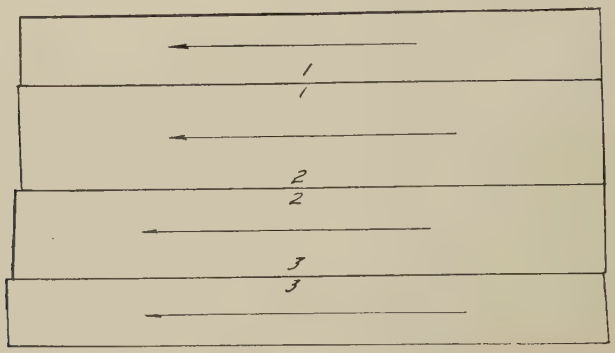


Fig. 158. Arranging boards for jointing

surfaces of all are up and so that the grain, if possible, runs in the same direction and forms pleasing patterns.

2. Mark the direction of the grain and the edges to be joined together. The faces are usually not planed until after the boards are glued. (Fig. 158.)

3. Place the boards to be joined, two and two, in the vise, so that both faces are out. (Fig. 159.) Long boards are further clamped together with a hand screw at each end. (Fig. 160.)

4. Plane the two edges at the same time. Even if the edges are not planed absolutely square to the sides, the angles of both are still equal, and when one is placed on top of the other (Fig. 159), the faces will be in line.

5. It is of the utmost importance that the edges of both boards make a good joint at both ends, because wood dries faster at the ends, and, therefore, shrinks more rapidly, causing the joints to open. For this reason, it is advisable to plane the edges of the boards in such a way that when one is placed on top of the other the joint will be closed at both ends, but there will be a slight opening in the center.

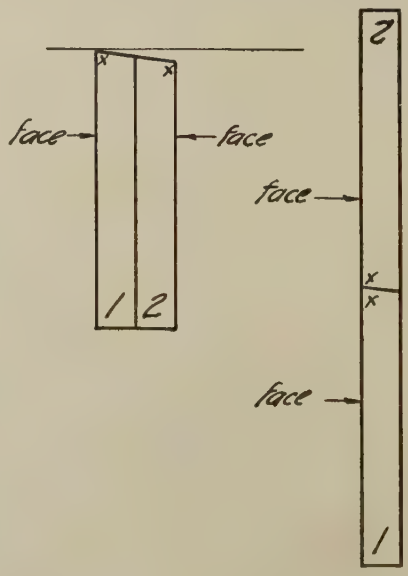


Fig. 159. Method of jointing two boards

6. If a single clamp is put on the boards in the center, they should come together over-all and the two ends should be tight.

7. The other edges are jointed in the same way, two and two.

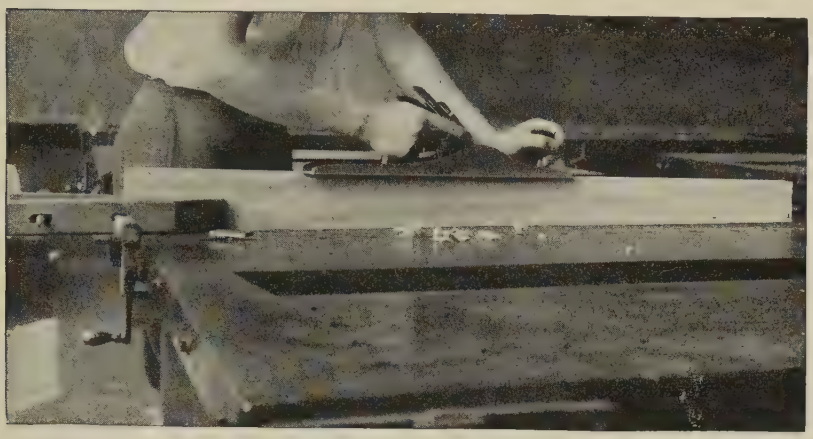


Fig. 160. Holding long boards in vise

140. To Square a Table Top. (1) Select the best face, remove any surplus glue with a chisel, clamp the table top securely to the top of the bench, and plane it *across the grain.* Start planing at one end, continue toward the other end, and repeat. It may be necessary to plane a small chamfer on the farthest end to prevent splitting.

Planing across the grain is especially recommended when working with cross-grained woods, like birch or mahogany, as it prevents tearing up the grain. Straight-grained woods, like white pine or cypress, may be planed lengthwise from the beginning of the work. Planing a surface across the grain is a good method of quickly evening it up and reducing it to size.

2. Test the surface frequently lengthwise, crosswise, and diagonally with a framing square. If, when placing the square diagonally, it touches at both ends, but not in the middle, and if, when placed diagonally in the opposite direction, it touches in the middle, but not at the ends, it is an indication that the board is warped or has "wind." This is remedied by planing the board in the diagonal direction first mentioned, when the square touches at both ends, but not in the middle.

3. When the surface is true over-all, it is planed lengthwise just enough to remove the marks of the cross planing. Use a very sharp cutter, and set it to cut a fine shaving.

If the wood is very cross-grained, it should be scraped with a cabinet scraper instead of planed.

4. Plane the best edge true and square to the face, and mark it as in Figure 154.

5. Square a line across the face from the working edge near one of the ends, using a framing square.

6. Saw off any surplus wood, and plane this end square to the working face and the working edge. Do not plane all the way across the end, but plane part way from both edges. Test for squareness with a framing square.

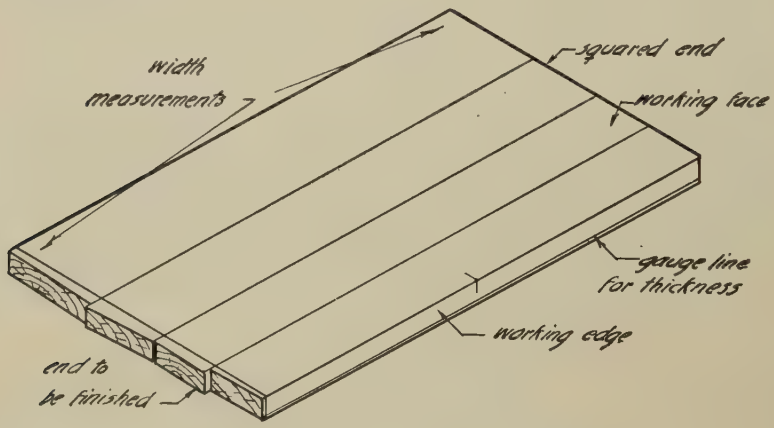


Fig. 161. Squaring a table top

7. Measure the length, square a line across from the working edge, saw off surplus wood, and plane the other end in the same manner as the first one was planed.

8. Measure the width at both ends, connect these points with a pencil line, and plane the other edge.

9. Gauge the thickness on both edges and ends from the working face.

10. Fasten the board face down to the top of the workbench, and plane the last face or underside to the gauge lines, as explained in steps 1, 2, and 3.

141. To Make and Square a Table Top, Using Machine Tools. (1) Cut the number of boards, which are needed to make up the top on the swing cut-off saw, allowing about ½ in. on the length for squaring.

2. If the boards are not absolutely straight, but are a little in "wind," plane one of the faces of each board on the jointer until it is perfectly flat. Then plane the two edges square to this face, except on the outside boards, where only one edge needs to be planed.

3. Clamp the boards together without glue, taking into consideration the matching of the grain and the direction in which it runs. (Arts. 139 and 189.)

4. Glue and clamp according to directions given in Article 189.

5. After the glued top is dry, plane it on the planer. Place the planed side of the boards down, and take a light cut the first time. If the machine makes a rough cut, turn the top around and feed the opposite end first. When this surface is smooth, reverse the top, and plane the surface planed on the jointer until the top has been reduced to the required thickness. Note the arrows indicating the direction of the grain. (Fig. 158.)

6. Plane one edge on the jointer, measure the length, and square lines across both ends. If the top is too large to be cut across on the circular saw, it may be cut on the band saw.

Fig. 162. Testing for "wind"

7. The ends are usually squared with a hand plane. Although end wood can be planed on a jointer, this method is not to be recommended.

8. If the top is not too wide, it may be ripped to width on the circular saw. In this case, the ripping fence is set to the proper width, and the top run through without further measurement.

9. When the top is wider, the width is measured from the planed edge, and a pencil line is drawn from one end to the other. The waste is sawed off on the band saw, and the edge planed on the jointer.

10. The top may now be sanded smooth on a drum sander, or a belt sander, or with a portable sander. No hand planing or scraping is necessary when a sanding machine is available.

142. **To Square Legs for Tables and Cabinets.** (1) Cut the legs (usually four) to dimensions, allowing sufficiently for squaring. If the

lumber is free from defects, $\frac{1}{16}$ in. to each side should be sufficient. For example, a leg that should measure $1\frac{1}{2}$ in. square when finished, should be about $1\frac{5}{8}$ in. in the rough. It is well to allow $\frac{1}{4}$ in. on the length.

2. Select the best two adjoining sides on each leg, and plane them

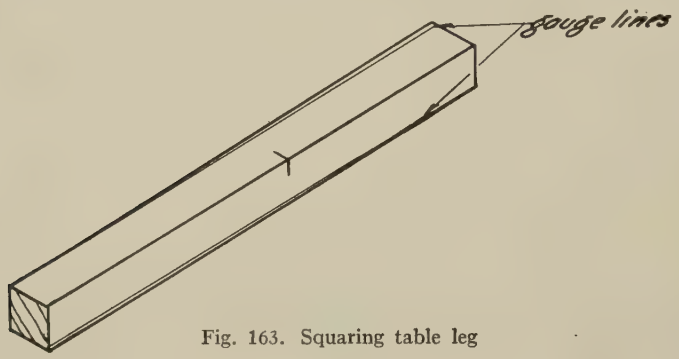


Fig. 163. Squaring table leg

true and square to each other. Test each surface planed for "wind" by placing it on a level surface. (Fig. 162.) Mark the sides squared.

3. When two faces have been squared on each leg, the marking gauge is set to width, and lines are gauged on all legs with the same setting of the marking gauge. (Fig. 163.)

4. The remaining sides are then planed to the gauge lines square to the first two sides planed. The ends are usually cut to exact length after other members have been joined to the legs.

When turned legs have square sections, the procedure is the same. When the work has not been properly centered, the turned part will be nearer to one or two sides than to the others. Those near sides are first squared, so that the greatest amount of material is removed from the other or far sides, thus correcting the error of centering as much as possible. (Fig. 164.)

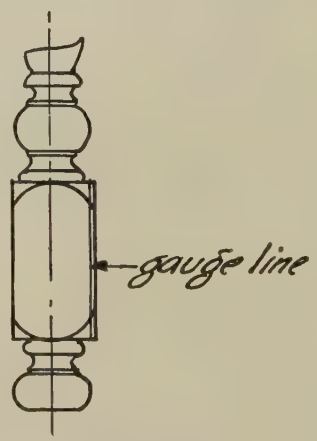


Fig. 164. Squaring part of turned leg

143. To Taper Square Legs for Tables and Cabinets. (1) After the legs have been squared, as explained in Article 142, the part to be tapered is measured off and a pencil line squared all around each leg.

2. A marking gauge is then set to the amount of the taper, as for

example ¼ in., and four lines are gauged on the end of each leg. The lines of taper are then drawn on two opposite sides with a straightedge from these points to the pencil lines. (Fig. 165.)

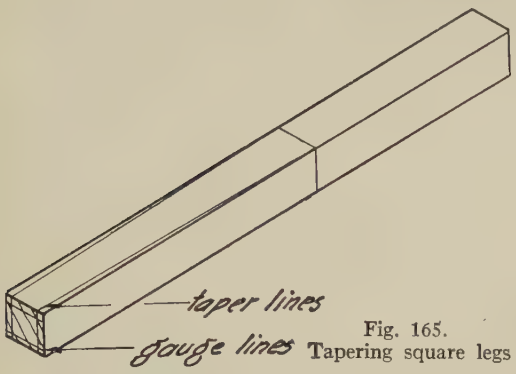


Fig. 165. Tapering square legs

3. If the amount of material to be removed is considerable, it is advisable to saw it off before planing the sides true to the lines.

When two opposite sides have been tapered, the taper lines are laid out on the remaining two sides, and the processes are repeated.

144. To Taper Square Legs for Tables and Cabinets on the Circular Saw. (1) Suppose the legs are to be 2 in. square and 30 in. long;

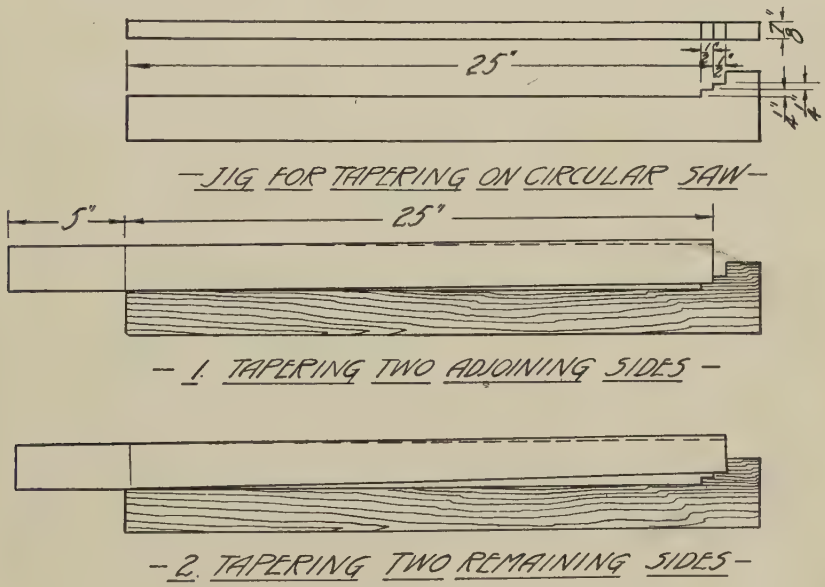


Fig. 166. Tapering square legs on the circular saw

plane two adjoining edges on the jointer, set the ripping fence on the circular saw to 2 in. full, and rip with the planed edges always against the fence.

2. If the taper is to be ¼ in. on each side and begins 5 in. from the top, make a jig as shown in Figure 166. The notches, as will be seen, are ¼ in. each.

3. Square a line all around each leg 5 in. from the top. Place the other end of the leg in the inner notch as shown. Measure the combined width of the leg and jig at the 5 in. line. and set the ripping fence accordingly.

4. Rip two adjoining sides, then place these successively in the other notch, and rip the remaining two sides. The leg is now tapered equally on all four sides.

5. Smooth on a disk or belt sander, or with a portable sander.

REVIEW QUESTIONS

1. What two methods may be used to prevent splitting, when planing end grain on narrow boards?
2. If the surfaces of a board to be squared are numbered in the order in which they should be planed, what is the sum of the numbers of any two opposite surfaces?
3. What is the advantage of having the grain of the boards forming a table top running in the same direction?
4. Boards to be glued edge to edge should be planed.....
5. How may the jointing of two edges be tested?
6. What are the advantages of planing a table top across the grain?
7. What precaution should be taken to prevent splitting at the edges when planing across the grain?
8. How is "wind" in a board detected?
9. How is "wind" taken out of a board by hand planing?
10. How is the end of a wide board planed?
11. How is the underside of a table top reduced to the required thickness?
12. Why is the surplus glue removed with a chisel before planing?
13. What are the machine processes involved in making a table top?
14. What is the advantage of squaring only two sides of the legs for a table at a time?
15. How are square sections on turned legs planed to size?
16. Why are legs squared before they are tapered?
17. Why are the taper lines not laid out on all four sides at the same time?
18. How are square legs tapered on the circular saw?

CHAPTER V

GROOVED JOINTS

Grooved joints are a group of joints which have the following characteristics in common: They all have a groove or recess cut into one member, either with the grain or across the grain, into which the edge or end, in whole or in part, of another member is fitted. This type of joint is used extensively in all cabinet construction, as for example, in door, panel, and drawer construction, in shelving, picture frames, built-in furniture, etc. The carpenter uses grooved joints in flooring, wainscoting, tank construction, store fixtures, etc.

146. **To Make a Rabbet Joint.** (1) Adjust the plane iron for the thickness of the shaving as in ordinary planing. Be sure that the blade projects evenly through the bottom of the plane. See that the edge of the blade is exactly in line with the side of the plane.

2. The spur, which is fastened to the side of the plane with a little screw, is now set to a cutting position. It is important to have it sharp.

3. Set the two gauges on the rabbet and fillister plane to the desired width and depth. (Fig. 43.)

4. Fasten the board to be rabbeted to the bench. Hold the plane level, and press the width gauge against the edge of the board. Take every stroke evenly and carefully. The spur scores the wood so that the rabbet will be cut to an even width. Continue until the depth gauge bears against the upper surface of the board.

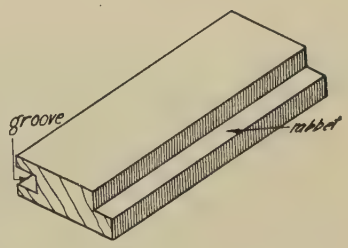


Fig. 167. Groove and rabbet

It may be found advantageous for the inexperienced to nail or clamp a strip of wood to the piece, as an additional guide for the rabbet plane.

147. **To Make a Dado Joint.** (1) Square both members to dimensions.

2. Measure the thickness of B and lay it off at the desired point on A. Square lines across A at these points, using a knife or a fine pencil point. Test the measurement by placing B perpendicularly on A. (Fig. 168.)

3. Gauge the depth on A; it is usually less than half the thickness of A.

4. Cut a small groove on the inside of each of the lines squared across the board, in which to start the saw. (Fig. 169.) This is done as follows: Hold the board against the stop on the bench hook, place a try-square right on the line, and score with a

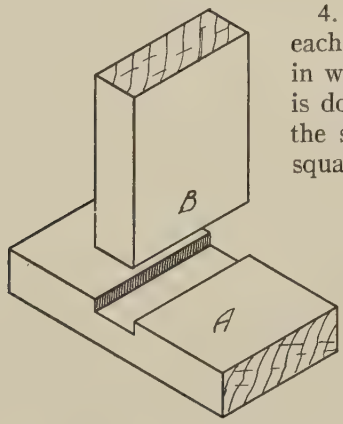


Fig. 168. Dado joint

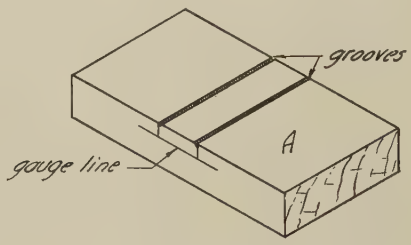


Fig. 169. Dado ready for sawing

knife along its edge. (Fig. 196.) Cut as deeply as possible. Holding the chisel horizontally with the beveled side up, and cutting across the grain, a triangular groove is now formed. (Fig. 197.)

Instead of cutting the triangular groove, a block of wood may be clamped along the line where the saw cut is to be made. The block will act as a guide for the saw. (Fig. 169*a*.)

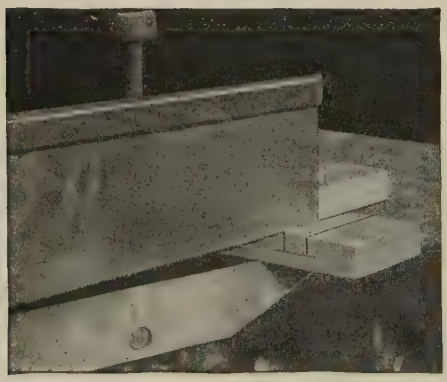


Fig. 169*a*. Block hand-screwed to piece guiding backsaw

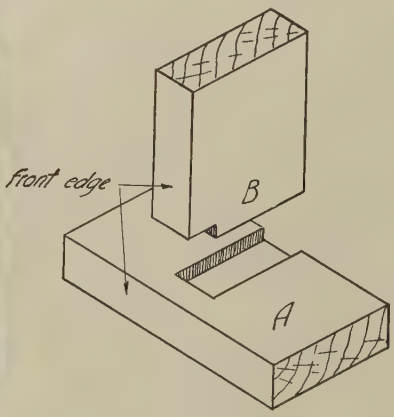


Fig. 170. Gain joint

5. Remove the wood between the saw cuts with a chisel and finish with a router plane. (Fig. 172.) The latter method is preferred as the router plane can be set to cut all dadoes evenly and to the same depth. Chisel or plane from both edges toward the middle.

Dadoes also may be planed with a special plane called a "dado plane."

148. **To Make a Gain Joint.** (1) Square the members, and lay out the joint as explained in Article 147.

2. As the gain joint differs from the dado joint, in that it does not go all the way across piece A, lay off the distance where the dado stops on both members, which is about ½ in. from the front edge.

3. Gauge the depth on the rear edge of piece A, and also on the front edge of piece B. (Fig. 170.)

4. Chisel out the gain, using a ¾ in. chisel, and holding the beveled side toward the inside. Strike light blows with a mallet, being careful to follow the lines.

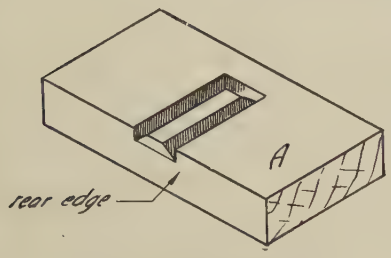


Fig. 171. Chiseling gain

5. Cut a small groove all around, and then go over it again striking heavier blows. (Fig. 171.)

6. Finish the groove with the router plane. (Fig. 172.)

7. Saw out the notch in the front edge of B, and fit the pieces together.

This joint is used on such pieces of furniture as bookshelves, where the dado joint would be unsightly.

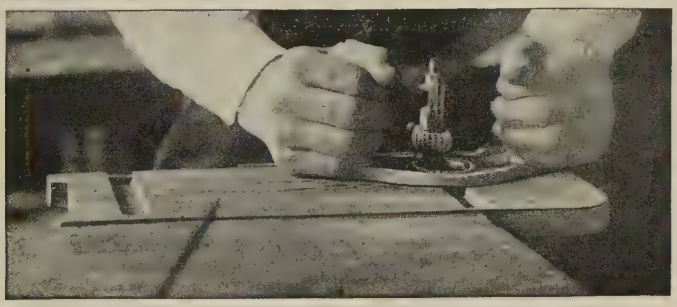


Fig. 172. Finishing gain with router plane

149. **To Make a Grooved Joint.** (1) A groove differs from a dado in that it runs along the grain. (Fig. 167.)

2. It is made in the same way as a rabbet joint; i.e., planed with a special plane called a "tongue-and-groove plane" or "plow-and-matching plane." (Fig. 44.)

3. This plane can be set to plane a groove on the edge of one board and a tongue on the other such as is used on flooring (matching).

Grooves are used in panel and drawer construction. (Arts. 174 and 176.)

150. To Make a Groove and Rabbet Joint. (1) Plane or chisel a groove in one member.

2. Plane a rabbet to fit the width and depth of the groove on the other member. (Art. 146.)

This joint is also called a barefaced, tongued joint, and is used where it is desired to have sides of cabinets come flush with the legs. (Figs. 173 and 408.)

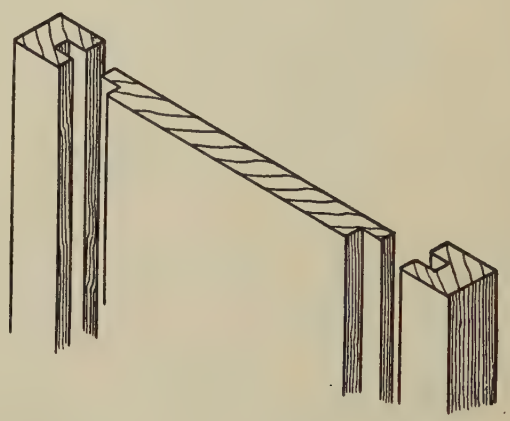


Fig. 173. Groove and rabbet or barefaced tongued joint

151. To Make a Dado and Rabbet Joint. This joint is like the groove and rabbet joint, except that it is made across the grain of the wood.

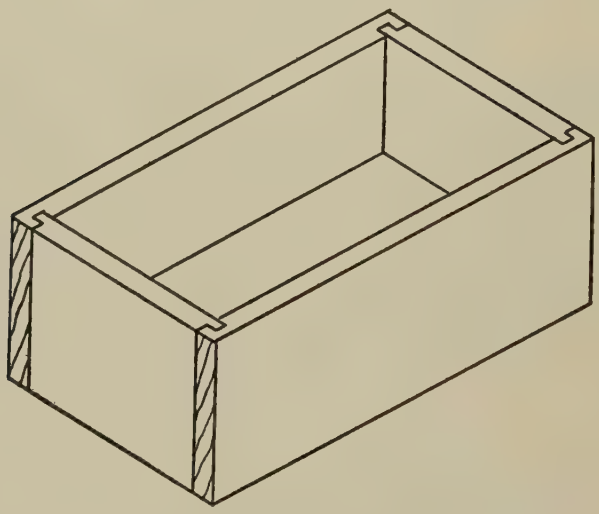


Fig. 174. Dado and rabbet joint

1. Lay out and chisel a dado on one member. (Fig. 169.)
2. Plane a rabbet to fit the width and depth of the dado on the other member. (Fig. 174.)

TO MAKE GROOVED JOINTS WITH MACHINE TOOLS

Grooves, dadoes, and rabbets are usually cut on the circular saw, on the shaper, or with a portable routing machine. The circular saw is used primarily for straight work, and the shaper for curved work. Either a dado head or plain saws may be used on the circular saw for this purpose.

152. Cutting Grooves, Dadoes, and Rabbets With a Dado Head. (Fig. 99.) (1) Screw the dado sleeve on the saw arbor, put on one of the outside cutters, then the inside cutters, and then the other outside cutter or saw. See that the thickness of the dado head is equal to the width of the groove to be cut taking the outside measurement of the dado head. If this is not so, change the inside cutters until one or more of the right thicknesses have been found. Put on the collars, and tighten the nut. Adjust the saw table so that the dado head has sufficient clearance, and tighten its screws.

2. Set the dado head to cut the required depth, and lock it in this position. Set the ripping fence at the correct distance. The machine is now ready for use.

3. Dadoes are cut with the same set-up of the dado head, but the miter gauge and sliding table are used instead of the ripping fence. If the outside cutters are sharp, they will cut very smoothly across the grain.

4. Gain joints or stopped dadoes can be cut only part of the way. They must be finished with a chisel.

5. Rabbets are cut by placing the board to be rabbeted between the dado head and the ripping fence. In this case, the dado head may be wider than the rabbet needed.

153. Cutting Grooves, Dadoes, and Rabbets With a Circular Saw. (1) Make one saw cut at one of the edges of the groove, move the ripping fence the width of one saw cut, and continue in this manner until the total width of the groove has been cut.

2. A dado may be cut in the same way with a crosscut or miter saw. A stopped dado must be finished with a chisel.

3. A rabbet is formed by making two saw cuts at right angles to each other.

4. A tongue fitting into a groove is formed by cutting a rabbet on both sides of the board.

A rabbet also may be planed on a jointer.

154. Cutting Tongues, Grooves, and Rabbets On a Shaper. Fasten the proper knives to the spindle, and adjust it to the correct height over the table. Adjust the guides and see that all screws are tight before starting the machine.

Dadoes and gains are best cut with a portable router machine. Bits of the proper size, and guides for straight or curved work, can be had with the machine. (See manufacturers' directions.)

REVIEW QUESTIONS

1. How may a grooved joint be defined?
2. Name six types of construction in which grooved joints are used.
3. What is the difference between a rabbet joint and a dado joint?
4. Why is it advantageous to plane a chamfer on the edge of a board before planing the rabbet?
5. What methods may be used in helping to guide the saw when making a dado joint?
6. How does a gain joint differ from a dado joint?
7. How does a groove differ from a dado?
8. Where is a barefaced, tongued joint used?
9. What is the advantage of a dado head over a plain, circular, saw blade when cutting dadoes and rabbets?
10. When would it be more advantageous to use the circular saw in preference to the dado head?

CHAPTER VI

DOWEL JOINTS

Dowels are used extensively in all modern furniture construction. They are used in reenforcing boards glued edge to edge, in segment work, and as a substitute for the mortise-and-tenon joint. A dowel joint can be made more rapidly than a mortise-and-tenon joint, and does not require as much skill. When well made, it is much superior to a poorly made mortise-and-tenon joint. The patternmaker uses dowels in split patterns.

Dowels are made of birch or maple. They are either smooth or grooved. The standard sizes measure from $\frac{3}{16}$ to 1 in. in diameter and 36, 42, or 48 in. in length. They also may be obtained in usual working lengths, pointed, grooved, and ready for use.

156. To Make a Doweled Butt Joint. (1) Square the pieces to dimensions.

2. Gauge a line through the center of the ends and edges to be joined from the face of each piece.

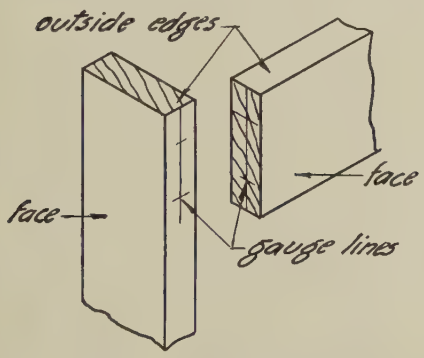


Fig. 175. Gauging for dowels

3. Determine the position of the dowels, and set the marking gauge equal to the distance between the outside edge and the center of the dowel nearest to it. With this setting, gauge lines crossing the center lines on all the pieces. (Fig. 175.)

4. Now set the marking gauge equal to the distance between the outside edge and the center of the next dowel, and gauge lines as before. The important point to remember is always *to gauge from the same sides and edges.*

5. Bore holes with an auger bit of the same size as the dowels, where all gauge lines on all the pieces intersect. The dowels should be of a diameter to give sufficient strength to the construction, without weakening the members to be bored. The diameter should be from one third to one half the thickness of the stock. Clamp an auger-bit gauge to the bit so that all the holes are bored to the same depth.

6. If a gauge is not available, one can easily be made by running the bit through a small block of wood, which is then cut to the right

length. (Fig. 176.) When this block of wood is slipped over the bit until it butts against the chuck of the brace, the bit should project the distance to which it is desired to bore the hole. (Fig. 201.)

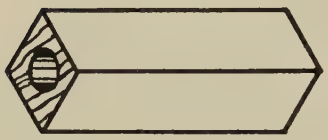


Fig. 176. Auger-bit gauge made of wood

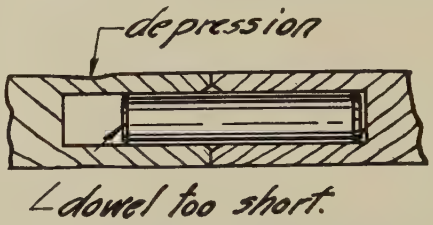


Fig. 178. Depression in surface caused by too short dowel

7. Watch the boring carefully so that all holes will be perpendicular when finished. It is recommended to stop boring after every few turns, and sight the work to determine if the bit is perpendicular both to the side and end of the board. (Fig. 177.) Any error may then be corrected before the holes are bored to their full depth.

8. Cut the dowels about ⅛ in. less in length than the combined depth of the holes. Point them a little with a knife or coarse sandpaper so that they may enter the holes more easily. Cut a small groove along the side of the smooth dowels to permit glue in the bottom of the holes to escape. Avoid making the dowels too short, as the wood around the hole, not filled, will shrink and make a depression in the surface. (Fig. 178.)

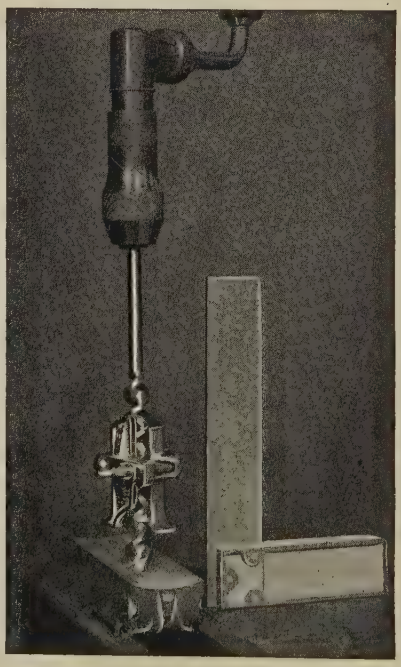


Fig. 177. Boring for dowel

9. Put glue in the holes of one member with a small round brush, or a small stick with a little cotton waste wrapped around one end. Dip one end of the dowels in the glue, and drive them home with light blows of a hammer or mallet. Wipe off surplus glue with a piece of waste.

10. Put glue in the holes and on the edges of the members which make contact and also on the dowels which protrude from the members into which they are glued. (Fig. 179.)

11. Join the pieces together and clamp. (See directions for clamping, Arts. 189 and 190.)

When boards for a table top are to be doweled together, they are placed side by side, and lines squared across the edges with a try-square. These lines intersect the center lines gauged from the face of the boards. (Fig. 180.)

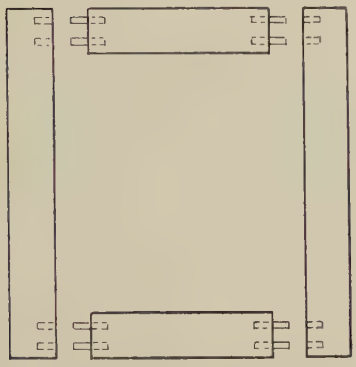


Fig. 179. Doweled frame ready for gluing

When the members are not joined at right angles as miters and segments, remember that the holes for the dowels are always bored at right angles to the edges to be joined. (Figs. 181 and 182.)

157. To Join Legs to a Turned Column With Dowels. (1) Sand the legs on a spindle sander or sanding cylinder in the lathe until the desired curvature has been obtained, so that they fit snugly against the column. (Fig. 291.)

2. Gauge center lines on the ends of the legs as described in Article 156, step 2. It is important that these lines be gauged exactly in the center, because the legs are to fit against a cylindrical column. If the holes to be bored for the dowels are a little off center, the joints will be open on one side.

3. Lay out vertical lines on the column at the points where the legs

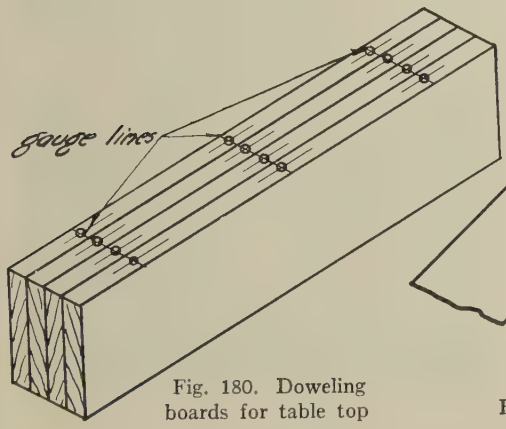


Fig. 180. Doweling boards for table top

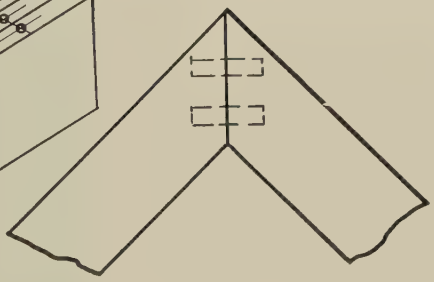


Fig. 181. Doweled miter joint

are to join it. This may be done as follows: Wrap a strip of paper around the column and cut it so that the ends just meet. Remove it and fold it into three or four equal parts, depending upon the number

of legs to be doweled into the column. Wrap the paper strip around the column again, and mark these divisions on it with a pencil. (Fig. 306.) Place the column in the lathe, move the toolrest of the lathe close up against it, and mark the lines along its upper edge from these points. (See also directions for reeding, Art. 236.)

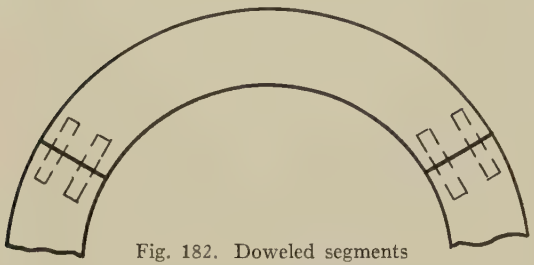


Fig. 182. Doweled segments

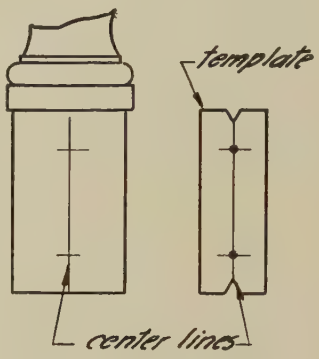


Fig. 183. Laying out for dowels on turned column

4. Make a template of cardboard of the same length as the joint, mark a center line on it, and punch two holes where the dowels should be. (Fig. 183.)

5. Place the template on the column and legs so that the center lines coincide, and mark the position of the dowels.

When the underside of the column is flat as in this case, the horizontal gauge lines may also be gauged on both column and legs by holding the block of the marking gauge against their lower edges. (Art. 156, step 4.)

6. Bore holes for dowels as explained in Article 156. (Figs. 177 and 184.)

7. Glue the legs to the column as explained in Article 196. (Fig. 242.)

Fig. 184. Leg joined to turned column with dowels

Holes for dowels may be bored on a boring machine or a mortiser with a boring attachment. If a number of similar pieces are to be bored, only one of them has to be laid out. The machine can then be set to bore the holes in the rest of the pieces

with the same spacing and at the same depth. See also Figure 206, showing how a turned column is clamped in a mortising machine.

A doweling jig (Fig. 185) insures straight and accurate hand boring, and is a valuable tool for the inexperienced. It can be clamped to straight surfaces and will take material up to 3 inches in thickness. The jig is furnished with cylindrical guides of different diameters, into which the bits fit. On cross-grained wood, it is recommended that twist bits be used instead of auger bits.

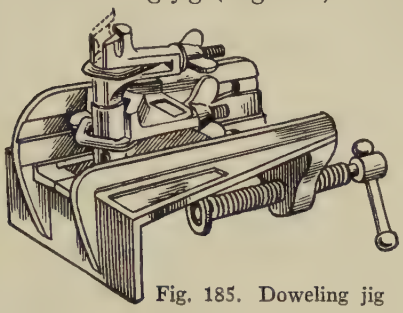


Fig. 185. Doweling jig

REVIEW QUESTIONS

1. Name three types of construction in which dowels are used.
2. Give three examples of cabinet construction in which dowels are often substituted for the mortise-and-tenon joint.
3. In what sizes and lengths and of what lumber may dowels be bought commercially?
4. How is a doweled butt joint laid out?
5. Why is a groove cut in the sides of smooth dowels?
6. What may happen if a dowel is cut too short?
7. How may a depth gauge for the auger bit be made of wood?
8. How may the ends of legs be shaped to fit against a turned column?
9. How are the centers for the dowels marked on the legs and the column?
10. What is a doweling jig?

CHAPTER VII

LAP OR HALVING JOINTS

In lap or halving joints, half the thickness of each member is cut away, so that when they are joined together their upper and lower surfaces will be flush. These joints are used both in carpentry, patternmaking and cabinetmaking. The carpenter uses lap joints in framing the timbers forming the sill and plate of a house and where timbers cross each other. The patternmaker uses them in making the arms for pulleys, etc. The cabinetmaker uses them in connecting crossrails

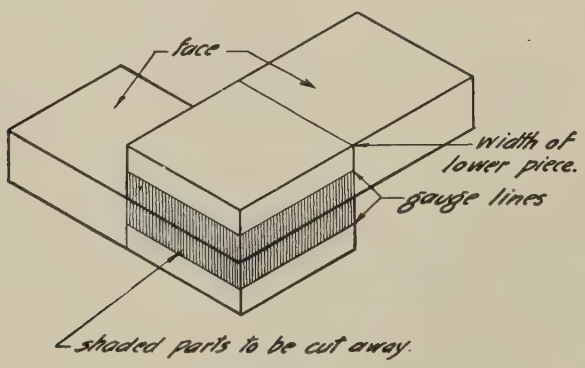


Fig. 186. Layout of end-lap joint

to the sides of a cabinet, in chair seats, in picture frames, in joining stretchers which cross diagonally, in molded work, and faced-up grounds for doors. These joints also have many other applications.

159. To Make an End-Lap Joint. (1) Square the pieces to dimensions.

2. Mark the face of each member plainly, and lay out the width of one on the end of the other, squaring lines all around each end.

3. Set the marking gauge to half the thickness of the pieces, and gauge lines around each end *from the face of each piece.*

4. Place the pieces on top of each other in the position they are to occupy when the joint is finished. Check measurements and mark the halves to be cut away. (Fig. 186.)

5. Put the pieces in the vise, end up, and saw on the waste side of the gauge lines, using a ripsaw, or if the pieces are small, a backsaw.

Begin the cut on the end wood, and saw diagonally until the saw reaches the shoulder line. Then reverse the piece, and finish the cut holding the saw horizontally. The first cut then acts as a guide for the saw, and insures greater accuracy. (Fig. 195.)

6. Cut small triangular grooves on the waste side of the lines where the pieces are to be sawed across the grain. (Figs. 196 and 197.)

7. Start the backsaw in these grooves while holding the pieces in the bench hook. (Fig. 198.)

8. The pieces should now fit together so that the upper and under surfaces are flush. (Fig. 187.) Any irregularity should be rectified with the chisel.

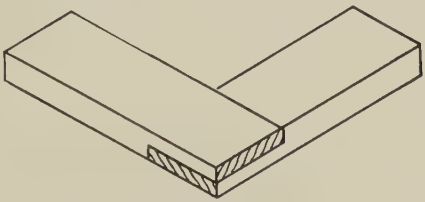


Fig. 187. Finished end-lap joint

160. To Make an End-Lap Joint with Rabbet. (1) Plane the rabbet first on all the members.

2. Proceed as explained in Article 159, but remember that the width of the rabbet must be subtracted from the total width of the piece when laying out the joint on the ends of the pieces.

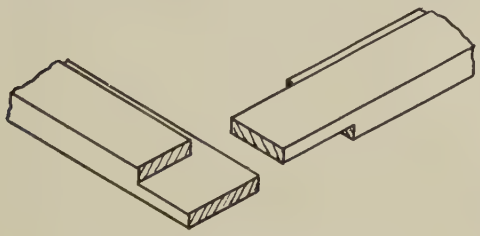


Fig. 188. End-lap joint with rabbet

3. The halving joints must be cut so that they are flush with the rabbet. (Fig. 188.)

161. To Make a Cross-Lap Joint. (1) Square the pieces to dimensions, making them exactly of the same length.

2. Mark the center on both pieces, and square a line all around.

3. Lay out half the width of the pieces to each side of the center lines, and square lines all around.

4. Place the pieces in the position they are to occupy, set the marking gauge to half the depth of the joint, and *gauge from the faces.*

5. Saw across the grain as shown in Figure 199.

6. Make one or two extra saw cuts to the gauge lines between the two cuts already made. This is done to serve as a depth gauge and to make the chiseling easier.

7. Remove the waste wood with a chisel and router plane as explained under dado joints. (Figs. 172, 189, and 190.)

162. To Make a Dovetail-Lap Joint. (1) Lay out the joint as explained in Article 159.

2. Cut away the waste piece on the member on which the dovetail is to be cut.

3. Lay out the dovetail and cut it as explained in Article 171.

4. Place this member in position on the second member, and mark the outline of the dovetail with a knife or fine pencil point.

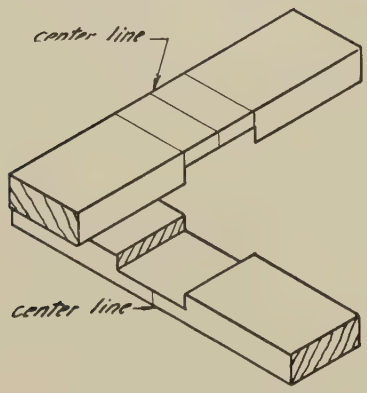


Fig. 189. Cross-lap joint

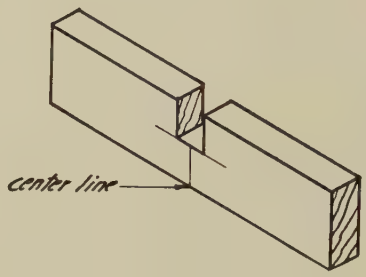


Fig. 190. Cross-lap joint on edge of board

5. Saw and chisel the recess marked, so that the dovetail will fit tightly and be flush on top. (Figs. 191 and 192.)

The dovetail also may be made straight on one of the edges. (Fig. 193.)

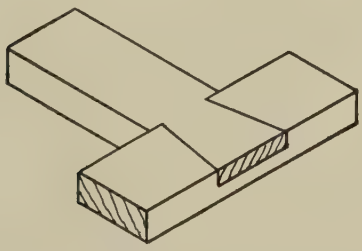


Fig. 191. Dovetail-lap joint

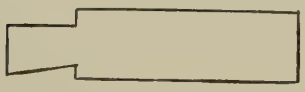


Fig. 193. Pin of dovetail-lap joint with one straight edge

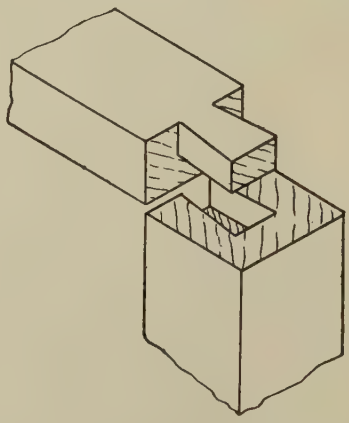


Fig. 192. Dovetail-lap joint (open)

Lap joints also may be made on machinery. The procedure in cutting end-lap joints is the same as explained for cutting tenons (Art. 169), except that end-lap joints have only one shoulder and one cheek cut.

Cross-lap joints and middle-lap joints also may be cut on the circular saw. In this case, however, the dado head should be used. (Art. 152.)

REVIEW QUESTIONS

1. What is understood by a lap joint?
2. Name five structures in which lap joints are used.
3. What is the important part in gauging the members of a lap joint?
4. How is a cross-lap joint laid out?
5. What may be done to help chiseling out the waste pieces accurately on the members of a cross-lap joint?
6. What tool may be used to smooth the chiseled surfaces of cross-lap joints?
7. Where is a dovetail-lap joint used in cabinet construction?
8. Which member is first cut when making a dovetail-lap joint?

CHAPTER VIII

MORTISE-AND-TENON JOINTS

The mortise-and-tenon joint is without exception the most important and most used joint in cabinet construction. It is made with several variations for different purposes. Some of the most important of these are carcase framing, door and panel framing, table framing, and chair framing.

The carpenter uses the mortise-and-tenon joint in joining cross members to posts, and in the building of any heavy substantial framework.

164. To Make a Blind Mortise-and-Tenon Joint. (1) Square the pieces to dimensions, and mark their faces plainly.

2. Determine the length of the tenon; i.e., the distance it is to enter the other member, and square a line all around its end at that point which is the shoulder.

3. Mark the total width of the tenon member on the mortise member at the point where they are to be joined.

4. Determine the thickness of the tenon; it is usually from one third to one half the thickness of the stock. Set the points of a mortising gauge to this distance, and adjust the block of the gauge, so that the double lines will be marked in about the center of the piece.

5. Gauge *from the face* on the end and edges as far as the lines marking the shoulder. (Fig. 194.)

Mark and gauge all tenons in the construction in the same manner before proceeding with the work.

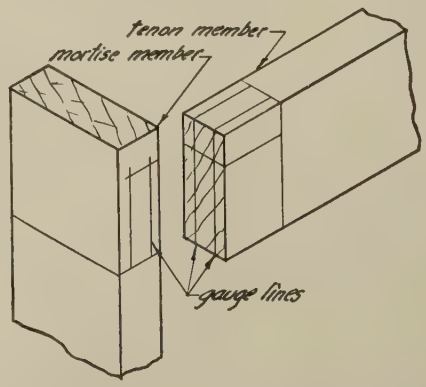


Fig. 194. Layout of mortise-and-tenon joint

6. If the faces of the members are to be flush, gauge the mortise with the same setting of the gauge from the face of the piece. If the mortise member is thicker than the tenon member, as for example in a table leg, and the rail or tenon member is to be set in, for example ¼ in. from the face of the leg, the block of the mortise gauge must be moved accordingly, *but not the setting of the two points.*

Gauge all mortises with the same setting of the gauge. If a mortising gauge is not available, an ordinary marking gauge may be used. In this case, all the face cheeks on tenons and mortises are first gauged, and then all the back cheeks.

7. A tenon is rarely made the full width of the member, but an additional cheek cut is laid out, making it narrower. If the mortise is near the end of a piece, the corresponding cheek cut is made so that the end wood of the mortise will not tear out when it is chiseled. Lay out this cheek cut on both tenons and mortises.

Fig. 195. Sawing cheek cuts of tenon

8. The laying out is now completed, after which the mortise is made. This may be done either by chiseling alone or by boring and chiseling.

9. In the first method, a mortising chisel of the same width as the mortise to be chiseled is used. Clamp the piece on top of the bench and begin by cutting out wedge-shaped pieces in the center of the mortise until the required depth is reached. This may be determined by gluing a strip of paper around the chisel. (Fig. 200.) Now make a series of perpendicular cuts toward both ends, holding the bevel of the chisel toward the cen-

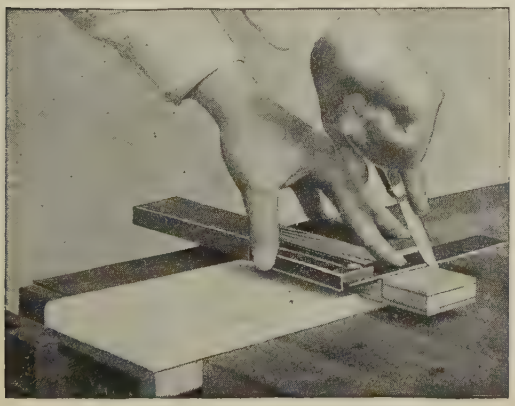


Fig. 196. Scoring line with knife

ter of the mortise. Break the shavings loose by moving the handle of the chisel toward the center of the mortise. Pare the ends of the mortise.

10. In the second method, a series of adjoining holes are bored with an auger bit 1/16 in. less in diameter than the width of the mortise.

Fig. 197. Cutting triangular groove in which to start the saw

(Fig. 201.) Clamp an auger-bit gauge to the bit, or make one of a block of wood (Art. 156, step 6) so that the hole bored will be slightly deeper than the length of the tenon. Be careful to bore the hole perpendicularly. (Figs. 177 and 201.)

11. Clamp the pieces firmly in the vise or on top of the bench, and chisel out the pieces of wood left between the holes bored. Chisel perpendicularly until the gauge lines are reached. (Fig. 202.)

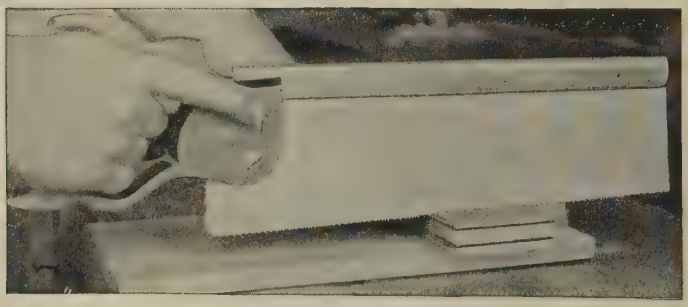


Fig. 198. Sawing shoulder cut

12. The cheek cuts of the tenons are sawed with a ripsaw or backsaw on the waste side of the lines. (Fig. 195 and Art. 159, step 5.)

13. Cut small triangular grooves on the waste side of the line indicating the shoulder cuts. (Figs. 196 and 197.) Saw the shoulder cuts with a backsaw as shown in Figure 198.

14. Bevel the sharp edges of the tenon slightly with a chisel. (Fig. 199.)

15. Fit the pieces together, and make any necessary adjustments. Only hand pressure should be necessary to bring the members of the joint together. Excessive force may cause the mortised member to split.

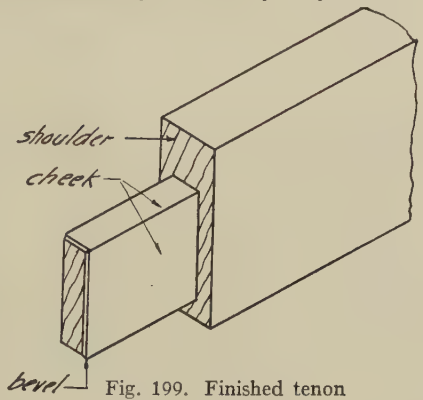


Fig. 199. Finished tenon

When the tenoned member of a blind mortise-and-tenon joint has only two cheek cuts, it is called a "stub mortise-and-tenon joint."

165. To Make a Haunched Mortise-and-Tenon Joint. (1) This joint is used in panel construction. Make the grooves first in all the pieces. These must be of the same width as the tenons are to be, which is usually one third the thickness of the members.

Fig. 200. Chiseling mortise. Note paper strip glued to chisel for depth gauge

2. Lay out the mortise and tenons, as described in Article 164, but do not extend the upper cheek cut all the way to the shoulder of the tenon. A piece of the tenon just large enough to fill up the groove is left at this point. (Fig. 203.)

The object of this joint is to give lateral stiffness.

A modified haunched joint is the table- or taper-haunched joint. (Fig. 204.) This is used on tables to give stiffness to the rails, or in places where the appearance of the regular haunched joint would be objectionable.

166. To Make a Through Mortise-and-Tenon Joint. (1) The procedure is the same as explained in Article 164, but in this case the tenon is made equal in length to the width of the mortise member, and the mortise extends right through the piece.

When wedges are driven into the end of the tenon this joint is called a "wedged mortise-and-tenon joint."

167. **To Make a Slip Joint.** (1) A slip joint is simply a through mortise-and-tenon joint made on the ends of two pieces. (Fig. 205.) In this case, the mortise, which is open on three sides, is sawed instead of bored.

Fig. 201. Boring series of holes for mortise

Fig. 202. Cleaning out bored mortise with chisel. Pressure of the shoulder forces the chisel into the wood

This joint is very strong and used on various types of frames. (Fig. 337.)

168. **To Make a Mortise on a Mortising Machine.** (1) Insert a mortising chisel and bit of the proper size in the machine, and see that the rear edge of the chisel is parallel to the vertical rear piece of the table.

2. Clamp the piece to be mortised in the machine. Press down the foot pedal, and bring the bit down near the top of the wood without starting the machine. Adjust the table so that the bit is centered between the two gauge lines, indicating the width of the mortise.

3. Adjust the machine to cut the desired depth, and see that the lengthwise movement of the table is set so that the entire length of the mortise can be cut without changing the position of the piece held in the clamp.

When several pieces are to be mortised alike, various stops on the table can be set so that the pieces are mortised automatically with the same spacing and length of mortise.

4. Start the machine, and bring the chisel down by stepping on the foot pedal. Make successive cuts next to the first cut until the entire length of the mortise has been chiseled.

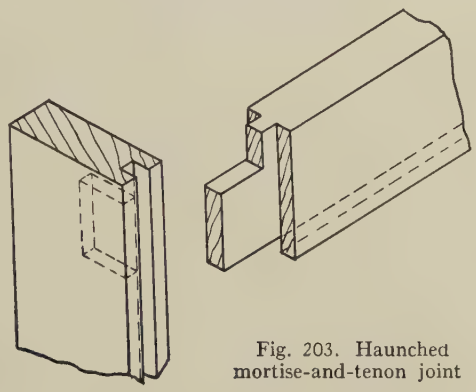


Fig. 203. Haunched mortise-and-tenon joint

When mortises are to be cut in turned stock, it is of the utmost importance to clamp the stock in the machine in such a way that the mortise, if continued, would pass right through the center of the turned piece. This may be accomplished as shown in Figure 206. A rectangular block of the same width as the diameter of the turned piece is cut on the band saw, so that it forms a rest or cradle for the cylindrical piece to be mortised. A line is marked in the center of the block as shown.

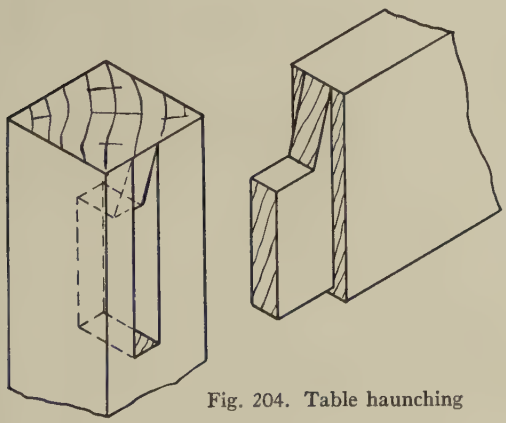


Fig. 204. Table haunching

Lay out the mortises on the turned column as explained in Article 157, Figure 183. From these points draw lines across the end of the column. Each line passes through its center and continues to the opposite side.

Place the column in the cradle, so that the lines coincide, as shown in Figure 206. Clamp securely and adjust the table so that the chisel is centered over the line marked on the side.

This method may also be used when legs are to be doweled to a turned column. (Fig. 184.)

169. To Cut Tenons on the Circular Saw. (1) Make the

shoulder cuts first, using a circular miter saw, or the ordinary cross-cut saw. (Fig. 207.)

2. Set the saw to the correct height above the table, and use one of

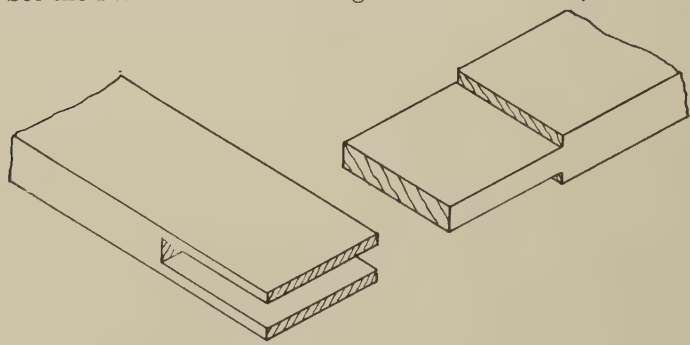


Fig. 205. Slip Joint

the universal gauges set at an angle of 90 deg. If several tenons of the same length are to be cut, the metal clearance block should be screwed to the ripping fence, which should then be set to the desired distance. (Art. 92 and Fig. 95.)

After the shoulder cuts on the side of the pieces have been made

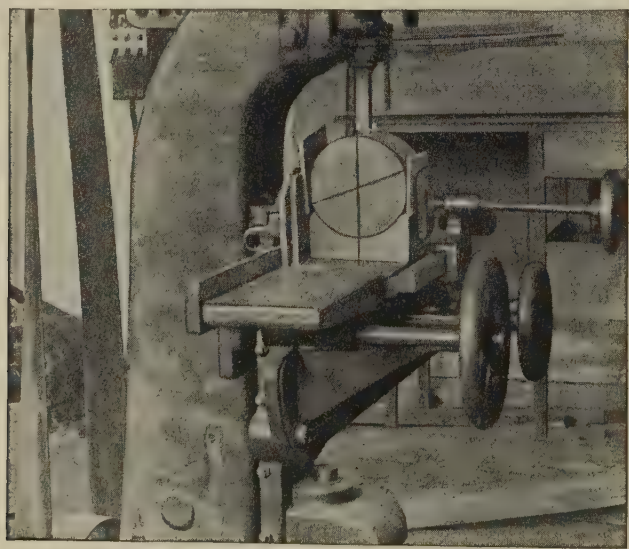


Fig. 206. Cutting mortises in circular stock

(Fig. 207), the height of the saw above the table should be adjusted for the shoulder cuts on the edges.

3. Either a ripsaw or a miter saw may be used for the cheek cuts.

These should be made from *the face side* only; i.e., the face side of the tenoned member is held against the ripping fence while cutting.

4. This fence is first set so that the saw cuts outside the line, indi-

Fig. 207. Making shoulder cuts on circular saw. The guard has been removed in order to make the operation more clear. Sawing should never be done without the guard in place

cating the cheek cut nearest the face side. All the tenons are now cut with this setting.

This is done so that the faces of the tenoned and mortised members will come as nearly flush as possible.

Fig. 208. Making cheek cuts on circular saw. The guard has been removed in order to make the operation more clear. Sawing should never be done without the guard in place

5. The ripping fence is then adjusted to the second cheek cut, the face side of the member being again held against the fence. (Fig. 208.)

6. Cut only one tenon, and fit it to the mortised piece. The members should fit tightly together, but not so tight as to cause splitting or bulging of the sides of the mortised member.

7. Make final adjustments of the ripping fence, if necessary, and cut the remaining tenons.

8. If the tenon is to be narrower than the width of the tenoned member, the additional cheek cuts may be made in the same manner.

In order to save time, two saws may be placed on the arbor and spaced so that the two cheek cuts on a tenon are cut at the same time. Large, flat, iron washers may be used as spacers between the saws.

Any fine adjustment of the spacing may be made by inserting washers made of cardboard.

A mortise-and-tenon joint may be reenforced with a square wooden pin or a dowel. A hole is bored or chiseled through both members of the joint, into which this pin or dowel is glued. When the glue is dry, the pin is sawed and planed smooth with the surface. This type of joint is called a "pinned mortise-and-tenon joint."

REVIEW QUESTIONS

1. Give ten examples of the use of the mortise-and-tenon joint in cabinetwork and carpentry.
2. How is a blind mortise-and-tenon joint gauged when the members are to come flush?
3. Define the terms "cheek" and "shoulder" of a tenon?
4. How is a mortise made by hand?
5. What is a haunched mortise-and-tenon joint, and where is it used?
6. How does a table-haunched joint differ from an ordinary haunched joint?
7. What is the difference between a through mortise-and-tenon joint and a slip joint?
8. How is a mortise cut on a vertical hollow-chisel mortising machine?
9. How may a number of tenons be cut to exactly the same thickness on a circular saw?
10. How are the shoulder cuts made on a circular saw?

CHAPTER IX

DOVETAIL JOINTS

This type of joint is the strongest and neatest of all joints used in cabinetmaking. As it takes both time and skill to make dovetail joints, they are used only in the better class of work. Dovetail joints are used mostly in drawer construction, in carcase work, and in box construction.

171. To Make a Through, Multiple, Dovetail Joint. (1) Square the pieces to dimensions.

2. Square a line around the end of each member equal to a trifle more than the thickness of the other member.

3. Determine the number of dovetails to be cut, and divide the end of one piece into that number of equal spaces. (Fig. 209.)

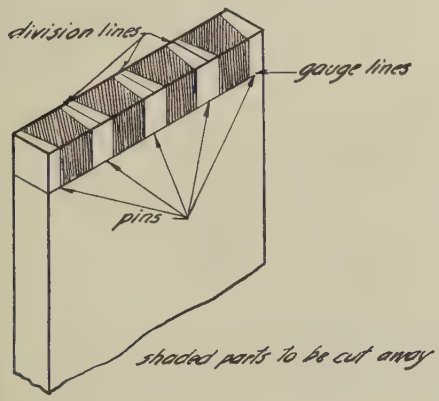


Fig. 209. Laying out the pins

The strongest joint is one having the tails and pins equal, but for the sake of appearance, the tails are usually made larger than the pins.

4. Square lines across the end of the board at the points of division. From these lines and from the sides of the piece, lay out a distance that is equal to one half the greatest width of the pin. (Fig. 209.)

5. Lay out the angle of the dovetails as follows: Square a line across a board, and step off six spaces with a divider. (Fig. 210.) At the sixth point, erect a perpendicular parallel to the edge of the board. Lay out one space on the perpendicular, and draw a line from this point to the edge of the board where the first line begins.

6. Set the sliding T bevel to this angle, holding the stock against the edge of the board and adjusting the blade to coincide with the line.

7. Mark the pins from the points laid out on the end of the board, as shown in Figure 209.

8. Square these lines down on both sides of the board.

9. Mark plainly the parts to be cut away. (Fig. 209.)

10. Saw on the waste side of the lines with a dovetail saw or a fine backsaw.

11. Chisel away the waste pieces, cutting halfway through the

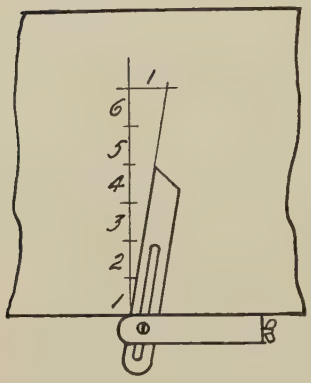


Fig. 210. Laying out angle of dovetails

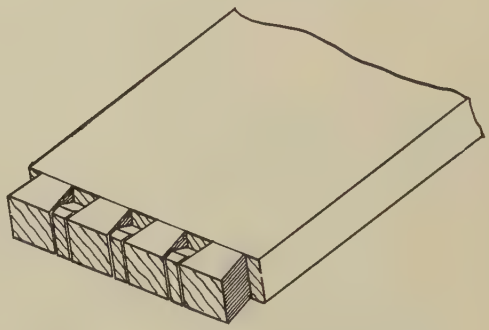


Fig. 211. Chiseling away waste pieces on tail member

board from one side, and then reverse the board and finish chiseling from the other side. (Fig. 211.) Be careful to make these cuts perpendicular, and do not go beyond the line.

Fig. 212. Marking tails

12. Having finished the pins, lay the other board on the bench with the working face up. Place the board with the pins on the end of this board, so that the widest part of the pins is on the gauge line.

13. Mark the shape of the pins with a scratch awl, knife, or fine pencil point on the side of the other piece. (Fig. 212.)

14. Square these lines across the end of the board with a try-square

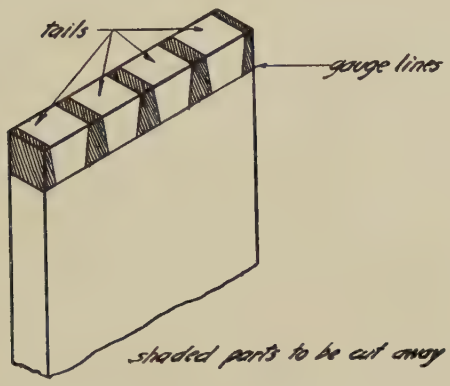


Fig. 213. Layout of tails

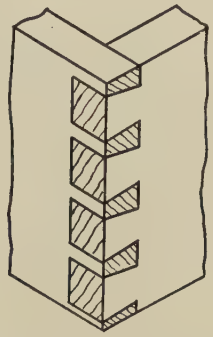


Fig. 214. Through, multiple, dovetail joint

and pencil, and also mark the angles with the T bevel on the other side of the board. (Fig. 213.)

15. Mark the waste pieces, and saw and chisel as before. (Fig. 211.)

16. Fit the pieces together, but do not force them so as to break or fracture any of the tails or pins. (Fig. 214.)

Some woodworkers prefer to lay out the tails first, especially if duplicate pieces are to be made.

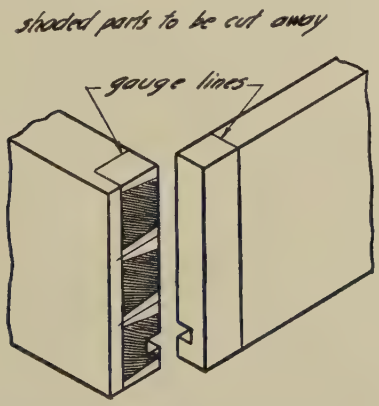


Fig. 215. Layout of half-lap multiple dovetail joint

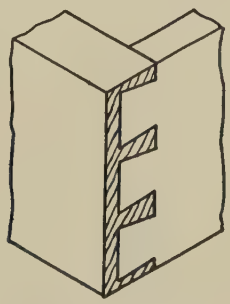


Fig. 216. Half-lap multiple dovetail joint

172. **To Make a Half-Lap, Multiple, Dovetail Joint.** This joint (Fig. 216) differs from the through dovetail joint in that the tails do not extend all the way through the joint and, therefore, do not show on one side. It is used in drawer construction.

1. Gauge a line on the end of one member, A, Figure 215, indicating the distance the tails are to extend.
2. With the same setting of the marking gauge, mark lines around the end of the other member, B, holding the block of the gauge against its end. These lines indicate the length of the tails.
3. Lay off the thickness of the member having the tails, B, on the other member, A.
4. Lay out, cut, and fit the pins and tails as explained in Article 171.

When constructing a drawer, the groove for the bottom should be plowed before the pins are laid out so that it will fall within one tail. (Art. 174.)

REVIEW QUESTIONS

1. Give two examples of dovetail construction.
2. How is the correct angle of dovetails obtained?
3. How are the pins on a multiple dovetail joint laid out?
4. What proportion in the size of tails and pins makes the strongest joint?
5. How are tails marked?
6. How does a half-lap, multiple, dovetail joint differ from a through, multiple, dovetail joint?
7. Why should the groove in the side of a drawer be cut in the center of one of the tails?

CHAPTER X

MISCELLANEOUS CONSTRUCTIONS

174. **To Make a Drawer.** (1) Get out the stock needed for the drawer; i.e., the front, two sides, the back, and the bottom.

2. Fit the front piece carefully to the opening the drawer is to occupy. It should fit rather tightly in this opening so as to allow for smoothing after the drawer has been put together.

3. Square the two sides to dimensions, and plow the groove for the bottom on the working face of these three pieces, one front and two sides.

4. Lay out, cut, and fit the dovetail joints. (Art. 172.)

In cheap work, a rabbet is simply cut on each end of the front, and the sides are glued and nailed in place.

5. Make the piece forming the back of the drawer equal in width to the distance from the top of the drawer to the groove. Its length should be equal to the inside distance between the sides plus twice the depth of the groove.

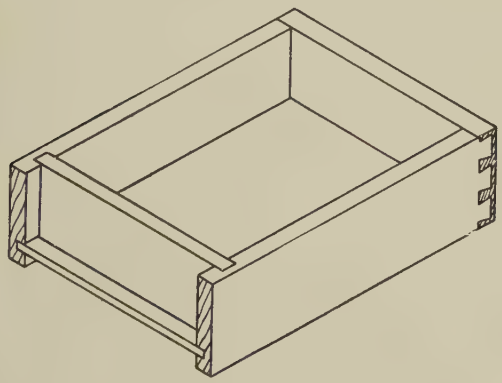


Fig. 217. Drawer

6. Cut the dadoes for the back on the sides of the drawer. They should be cut to the same depth as the grooves. (Art. 147.) A dado and rabbet joint may also be used for the back. (Art. 151.)

In the very best work, the back is joined to the sides with through dovetail joints.

7. The bottom, made either of plywood or of several pieces of wood glued together, is now planed and squared to dimensions. If necessary, bevel it on the underside to fit the grooves. If the bottom of the drawer has been made from several boards glued together, the grain, regardless of the width of the drawer, should always run from side to side and never from front to back. (Art. 301, page 237.)

8. Fit all the pieces together before gluing.

9. Glue the front, back, and sides together, and slide the bottom in place. (Fig. 217.) *Do not put glue on the bottom nor in the grooves.*

Apply the clamps test for squareness, and remove the surplus glue. (Art. 193.)

10. The bottom may be fastened by a triangular piece of wood glued to its underside and the lower inside edge of the front. It also

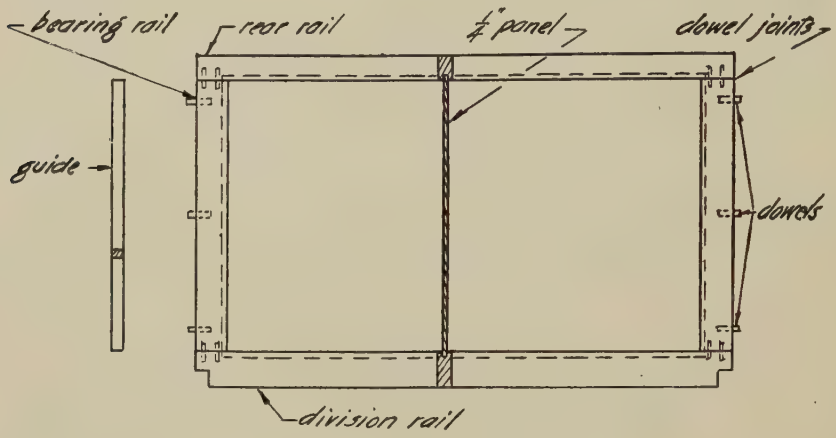


Fig. 218. Drawer-rail frame

may be nailed or glued to the underside of the back. It should always extend to the end of the sides to allow for shrinkage.

175. To Make Drawer Rails and Guides. The weight of a drawer is carried or supported on a framework called the "rails." Its movement is controlled by narrow cleats called "guides," which are fastened to the rails.

1. The rails usually consist of the front rail, or division rail, the rear rail, and two side rails, or bearing rails, mortised or doweled together. A thin panel usually is framed in between these rails. (Figs. 218 and 219.) When the drawer to be supported is very wide, an extra central rail, mortised into the front and rear rails is added to the framework.

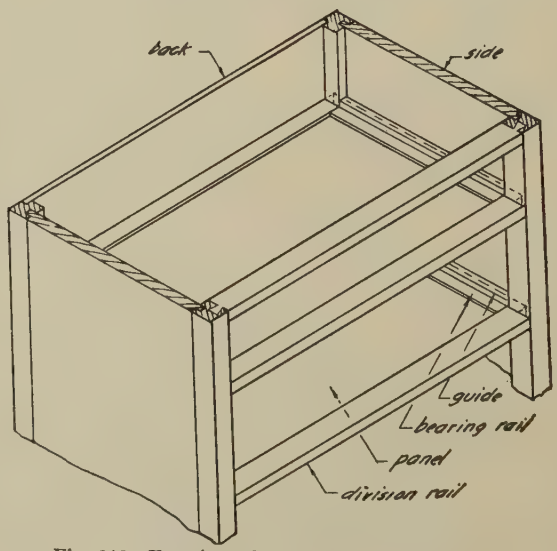


Fig. 219. Framing of drawer rails into cabinet

2. The guides consist of two narrow cleats of wood nailed or glued to the rails. Generally one guide is placed on each side of the drawer.

3. In some cases, however, it is more convenient to place the guides near the center, so that they form a channel for a narrow board glued

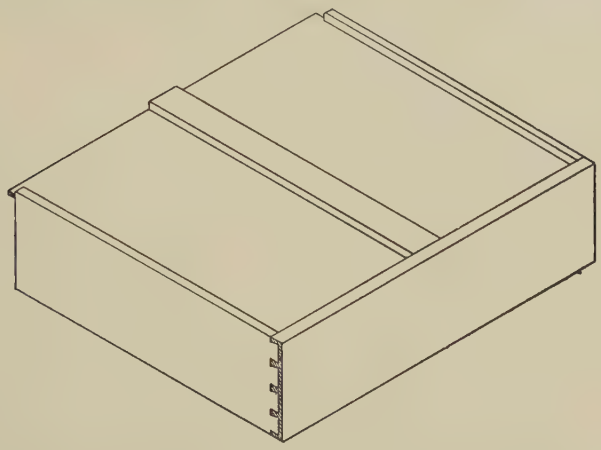


Fig. 220. Board glued to underside of drawer. Guides to be placed on each side of this board

to the underside of the bottom of the drawer. This board, about 1½ to 2 in. wide, runs from front to back, parallel to the sides of the drawer. It is made flush with the lower edge of the front of the drawer. (Fig. 220.)

4. The guides should be fitted so that the drawer runs easily and smoothly. A well-fitted drawer can be pushed in by pressing lightly on either side of it with only one hand.

5. Small blocks should be glued either to the rear or front rails for the purpose of stopping the inward movement of the drawer at the right point.

176. **To Make a Panel Structure.** The object in panel construction is to provide a means by which a large surface of wood can shrink or swell within a comparatively narrow frame, which also will prevent it from warping or twisting.

The best type of frame is joined with the haunched mortise-and-tenon joint (Fig. 203), but the slip joint (Fig. 205), the end-lap joint (Fig. 188), and the miter joint (Fig. 181) also are used.

1. Square the pieces forming the frame to dimensions. (Art. 138.) Plow a groove on the inside edges of the frame (Art. 149), and make the joints in the four corners. (Art. 165.)

2. The panel, which is made either of plywood or of several boards glued together, is dressed to dimensions and shaped, either flat or raised. (Figs. 221 and 222.)

3. Clamp the panel and frame together without glue, and then test for fit and squareness.

The panel should fit well in the grooves, not too loose and not too tight. It should be just a little shorter and narrower than the inside length and width of the frame plus twice the depth of the groove.

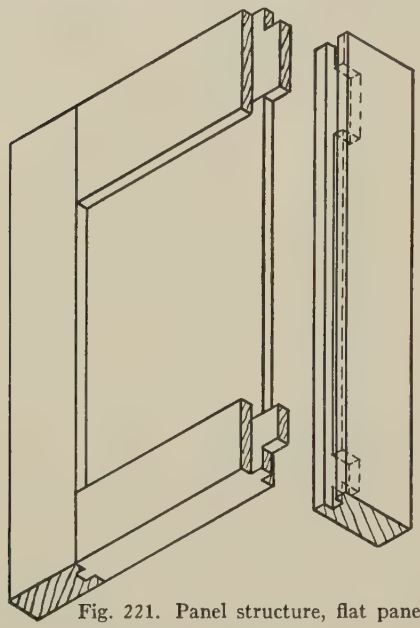


Fig. 221. Panel structure, flat panel

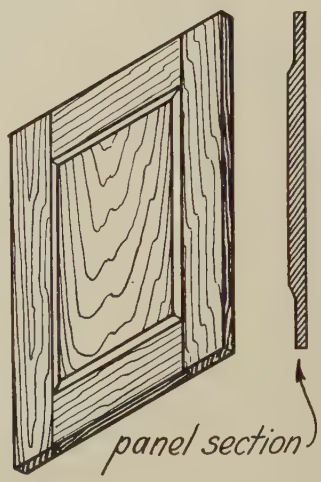


Fig. 222. Raised panel

4. Take apart and glue the joints at the four corners of the frame, but do not put any glue on the panel nor in the grooves.

177. **To Make a Miter Joint.** A miter joint is made by beveling the ends or edges of the pieces to be joined, to the desired angle. The most common example of the miter joint is the picture frame, in which the molding forming the frame is beveled to angles of 45 deg.

The miter joint is a neat but weak joint, and usually is reenforced in some way. In the case of cabinets, where moldings are glued to the sides and fronts or around panels (Fig. 423) the joint itself, of course, needs no reenforcement. In other constructions, some of the most common means of reenforcement are nails, dowels, and thin pieces of wood called slip feathers and splines. In carpentry, miter joints are used for rafters, moldings, fascia, plancier, drip cap, etc.

1. Determine the angle of the cut by dividing 180 by the number of sides in the construction. A few examples are as follows: A picture frame has four sides; the angle therefore is 45 deg. A hexagonal column for a table has six sides; the angle therefore is 30 deg. An octagonal column has eight sides; the angle therefore is 22½ deg.

2. It is recommended to cut these angles in a miter box, which is adjustable and has an automatic device for holding the saw in a vertical position. (Fig. 35.)

178. **Nailed Miter.** Drive nails at right angles to the bevel from the outside edges. Drive them until only their points pierce the beveled edges.

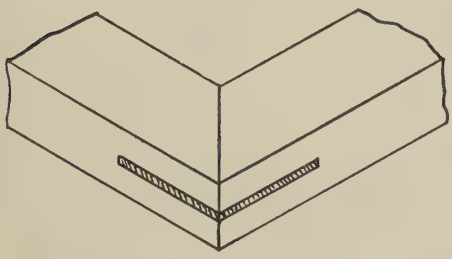


Fig. 223. Slip-feather miter joint

Clamp one piece in the vise in a vertical position, apply glue to both surfaces of the joint, place the other piece in position, and drive the nail slowly. If the upper piece slides down the bevel of the lower due to the driving of the nail, reverse the position of the pieces, and drive in the other nail.

179. **Doweled Miter.** Lay out and bore for dowels. (Art. 156.) Glue and clamp all pieces at the same time. (Fig. 238.)

180. **Slip-feather Miter.** Cut angles and glue all pieces at the same time. (Fig. 238.)

When dry, make a saw cut carefully in each corner, and glue a piece of very thin wood, or veneer, into this cut. (Fig. 223.)

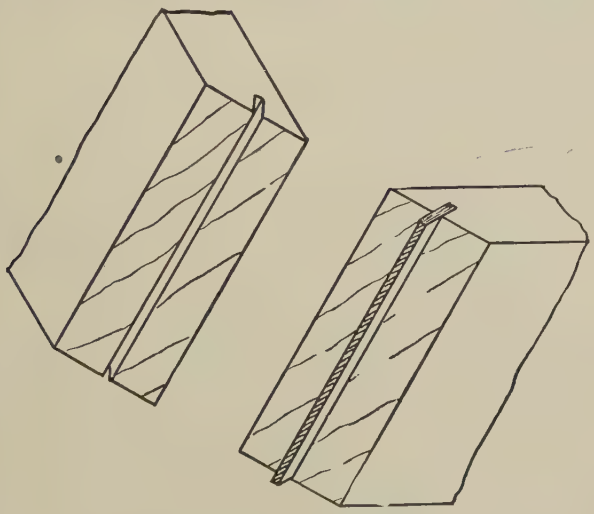


Fig. 224. Spline miter joint

When dry, trim and plane the corners.

181. **Spline Miter.** This method of reenforcement is used mostly on long miters, such as on columns or chests. Lay out and plane the angles carefully.

1. Cut a groove on both bevels at right angles to these, and equidistant from the corners. (Fig. 224.)

2. Prepare the spline, which is a thin piece of wood cut across the grain. It may be planed to thickness by inserting it in a shallow dado, cut in a board for that purpose. (Fig. 225.)

3. Glue the joint as shown in Figure 239.

182. **To Make a Rule Joint.** This joint is used on table tops, whose size is extended by means of drop leaves hinged to it. A table of this kind usually has one fixed part and two leaves. The rule joint, because of its neater appearance, is used instead of the butt joint on the better class of tables. (Fig. 226.)

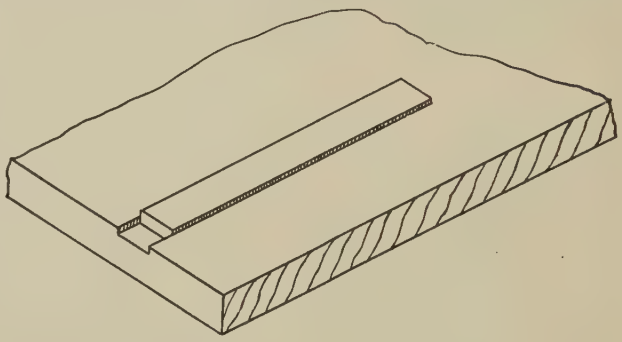


Fig. 225. Planing the spline

1. Square the pieces to dimensions, being particularly careful to see that the two edges are square and true.

2. Set the marking gauge to half the thickness of the knuckle of the hinge, then gauge lines on the end grain of the boards on both ends, holding the block of the gauge against the underside of the boards. (Fig. 227.)

3. Set a pair of dividers to about ⅛ in. less than the distance from the gauge line to the top of the board.

4. Beginning at the end of the fixed board, lay off this radius on the gauge line, and mark the center; then scribe a quarter circle as shown in Figure 227-1.

5. With the same radius, but using the point of intersection of the gauge line and the end of the board as centers, scribe a quarter circle on the leaf board. (Fig. 227-1.)

6. On the first board, plane a rabbet ⅛ in. deep and equal in width to the radius of the quarter circles. (Fig. 227-2.)

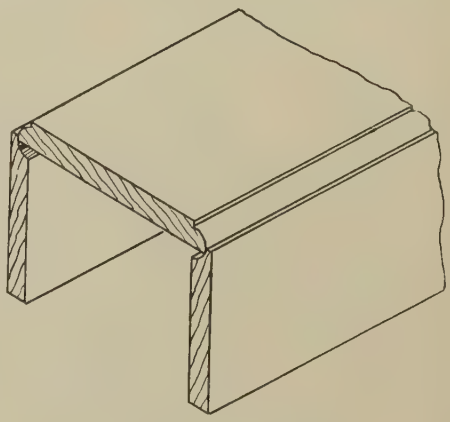


Fig. 226. Rule joint

7. Plane the concave and convex curves with molding planes, or work them out with chisel, gouge, and sandpaper. (Art. 244.) Use templates while shaping the curves. (Fig. 227-3.)

8. Fit the two pieces together, lay them face down on the bench, and apply the hinges.

One leaf of the hinge should be considerably longer than the other.

9. On the underside of the board with the convex curve, which is the fixed board, gauge a line from the edge of the board equal to the radius of the quarter circle. The knuckles of the hinges should be placed on this line.

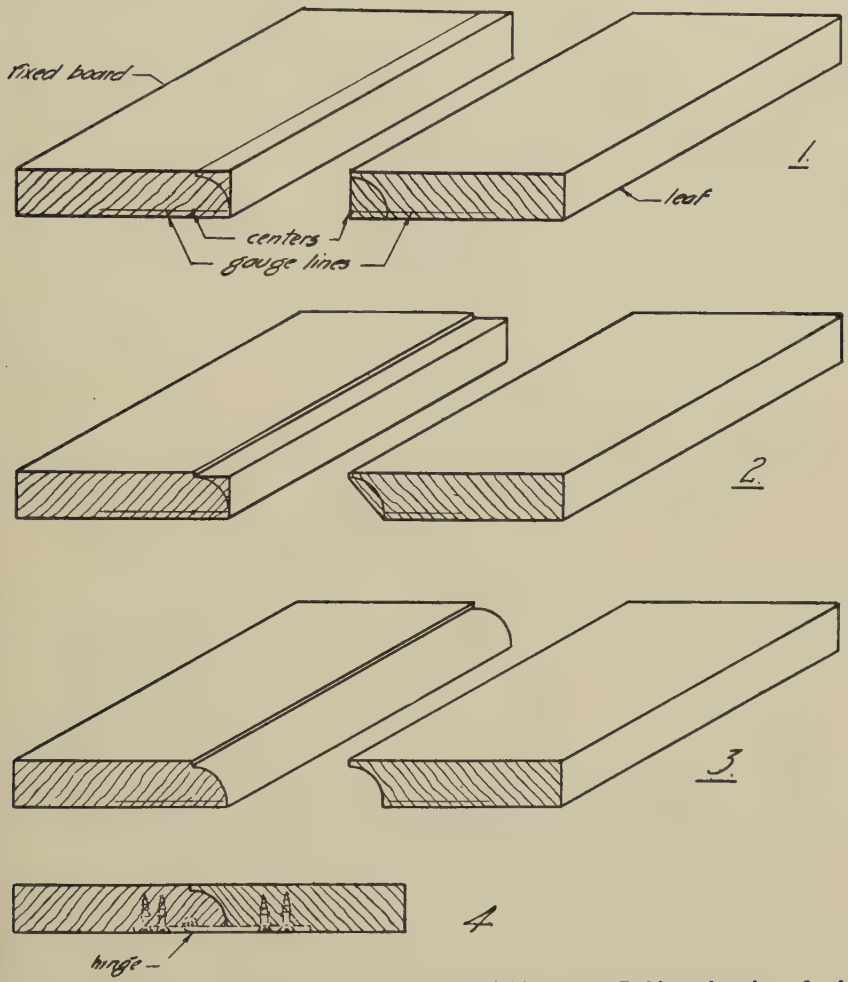


Fig. 227. Steps in making a rule joint. 1, Pieces laid out; 2, Rabbet planed on fixed board; 3, Convex and concave curves finished; 4, Hinging the boards

10. Set the hinges flush with the surface of the wood. They are placed in the reverse of the ordinary position; i.e., with the knuckle set into the wood. (Fig. 227-4.)

If the top has two leaves, as is usually the case, it follows that the two rule joints are laid out and worked simultaneously.

183. **To Make a Finger Joint.** A finger joint is a movable, interlocking joint made of wood. It is used chiefly to support the leaves of card and drop-leaf tables in a horizontal position. This is done either

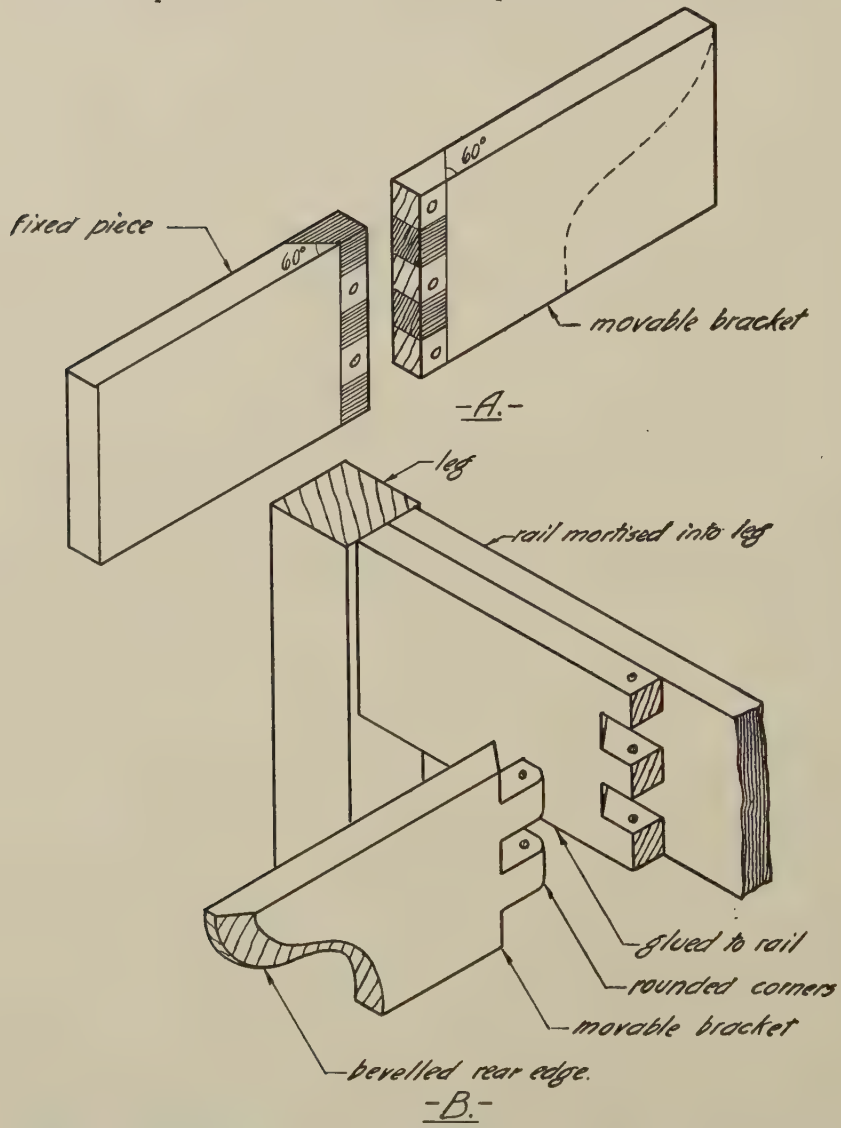


Fig. 228. Finger joint. A, Layout of the joint; B, Joint ready to be assembled

by means of a movable bracket, or by a table leg joined to a movable rail, called a "fly-rail." The joint used between the movable and fixed parts of these brackets or rails is the finger joint. (Fig. 228.)

1. Square the two pieces, of which the bracket or rail consists, to dimensions.

2. Divide the width of the boards into five equal parts. Lay off these divisions on one end of each board, and square lines across the ends from these points.

3. Set a marking gauge equal to the thickness of the boards, and with this setting, gauge a line on the face of both boards, holding the block of the marking gauge against the ends of the boards just marked.

4. From these gauge lines, lay off lines at an angle of 60 deg. across the upper edges of the board. From the points where the 60-deg. lines meet the rear edges, gauge or square lines across the rear faces of the boards.

5. The division lines squared across the ends are now carried around on both faces of the boards until they intersect the gauge lines.

6. The boards should then be placed end to end, the parts to be cut away should be marked, and saw cuts made on the waste side of the lines. Use a backsaw or a dovetail saw for this work, and chisel out the waste pieces.

7. Fit the joint together, and mark the center where the hole is to be bored for the pin. Place the pieces at right angles, and bore the hole. A 5- or 6-in. nail may be used as a pin.

It is advisable to bore the hole on a boring machine or in a drill press, if one is available, in order to insure perpendicularity.

8. When the joint is pinned together, it will be seen that the "fingers" on the movable piece will project a little when it is half open. These ends should now be rounded off as shown in the drawing.

9. The end of the movable part of the bracket is usually shaped and beveled on its rear side, so that it may be easily grasped with the hand.

10. The other part of the bracket is glued or screwed firmly to the fixed rail of the table.

184. To Make Slide Supports. (1) A slide support for a hinged table leaf consists of three narrow boards, each about 1½ in. wide and 1 in. thick. The length depends upon the size of the leaf.

2. A tongue is cut on each edge of the central board, or "slide," and a corresponding groove is cut in one edge of each of the other two boards, or "bearers." The tongues should fit in the groove, so that the slide will move easily between the bearers. (Fig. 229.)

3. The bearers are fastened to the rails as well as to the underside of the top.

4. A notch is cut in the table rails for the slide and bearers.

5. A stop usually is placed both on the slide and on the leaves. These stops limit the movement of the slide.

6. The front edge of the slide is either shaped or provided with a knob by which it can be pulled out under the leaf of the table.

185. **To Make a Checkerboard.** (1) A checkerboard may be made of ebonized wood, or imitation ebony, and maple or birch strips about ⅛ in. in thickness. (Fig. 230.)

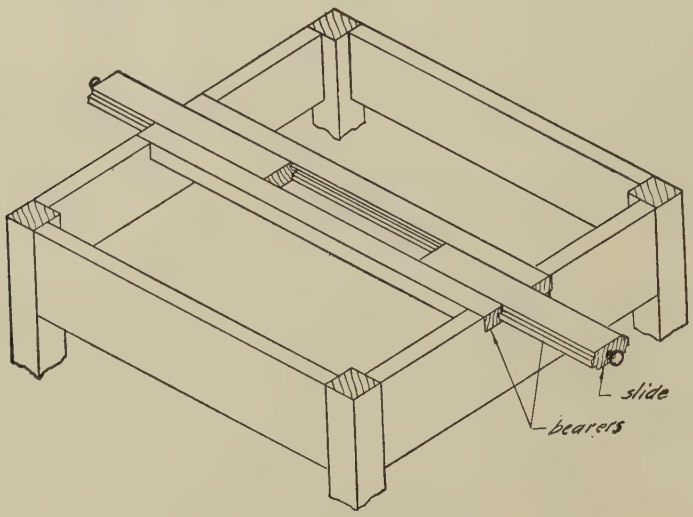


Fig. 229. Slide supports

Ebonized wood is a hard wood, which has been dyed jet black. This color penetrates to every particle of the wood substance. Ebonized wood may be obtained in sheets about ⅛ in. in thickness.

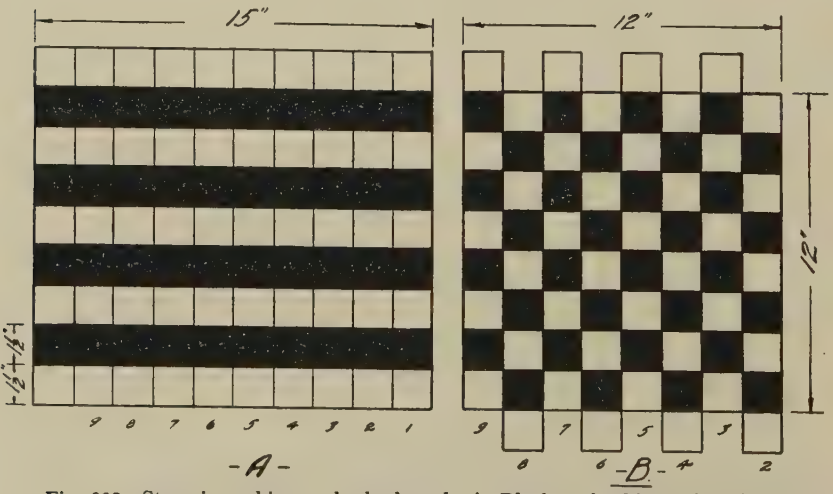


Fig. 230. Steps in making a checkerboard. A, Black and white strips glued together and marked for crosscutting; B, Strips, after being cut, placed so black and white squares alternate

2. If you want to make each of the white and black squares 1½ in. on the edge, proceed as follows: Use a very sharp circular miter-saw blade, and set the fence of the saw to 1½ in. Cut four strips of the black wood and five strips of the light wood, making each strip about 15 in. long.

3. Glue these strips together along their edges, alternating the black and white strips. Use the following method: Fasten four cleats at right angles to each other to a board or other flat surface so as to form a square measuring 14¼ by 15¾ in. inside the cleats. (Fig. 238.)

4. Place a piece of strong paper on the board. Spread thin glue on one face and one edge of one of the white strips. Place the glued face down in contact with the paper, so that the unglued edge butts against one of the cleats, and one of the ends against one adjoining cleat.

5. Spread glue on one face and both edges of one of the black strips. Place the glued face down on the paper, one of the edges against the white strip, and one end in line with the end of the white strip.

6. Continue in this way until all of the nine strips have been glued edge to edge. (Fig. 230, A.) Work rapidly so that the glue will not cool and thicken.

7. Drive four pairs of double wedges between the glued-up strips and two adjoining cleats (Fig. 238), thus forcing the sides and ends of the strips tightly together and against the other two cleats. It is also necessary to clamp two pieces of wood across the strips in order to keep them flat against the bottom of the board.

8. When dry, remove the hand screws and wedges. The glued strips are now cut across the grain, making strips of exactly the same width as each black and white strip.

It is better if the saw can be left untouched between the first and second cutting, as this insures exact width.

9. Discard the first strip that is cut, but take the next eight strips and place them so that the black and white squares alternate. (Fig. 230, B.)

10. The white squares, which project on two sides, are now carefully cut away with a sharp chisel, after which the strips are glued, wedged, and clamped as before.

11. When the checkerboard is dry, any slight unevenness in the edges may be removed with a sharp plane. Place the checkerboard between two hardwood boards with straight edges. Clamp the boards together in such a way, that the edge of the checkerboard, which is to be planed, projects a little above the edges of the boards between which it is clamped.

12. The checkerboard should now be smoothed carefully on the unpapered side, after which it may be glued to or inlaid in a solid board. Glue is applied to the unpapered side. (Art. 235.)

REVIEW QUESTIONS

1. Describe three types of drawer construction.
2. Why should the grain in a drawer bottom, made from solid wood, always run from side to side and never from front to back?
3. Why is a drawer bottom not glued into the grooves in the side pieces? What might happen if it were?
4. Give two reasons why a panel is framed in between the bearing rails of each drawer in the best work.
5. What simple test may be applied to determine if a drawer is well fitted?
6. What advantages has a panel structure over a solid board structure?
7. Why should a panel be made slightly shorter and narrower than the inside dimensions of the frame plus twice the depth of the groove?
8. What are the most common means of reenforcing a miter joint?
9. Why is a miter joint a weak joint?
10. How is the angle of a miter joint determined?
11. How may a picture frame be glued and nailed without any special miter clamps?
12. How is a slip-feather miter joint made on a picture frame?
13. How do a slip-feather and a spline miter differ?
14. Why does the grain in a spline always run the short way?
15. For what purpose is a rule joint used?
16. What type of hinges are used for the rule joint?
17. What is a finger joint, and where may it be used?
18. What is the difference between a "bracket" and a "fly rail"?
19. Why is the end of a bracket beveled on its rear side?
20. When would a slide support be used on a folding table in preference to a bracket?
21. How may a checkerboard be glued?
22. Why are the black and white strips of wood glued to paper?
23. How may the edge of the checkerboard be planed safely?
24. When the checkerboard is inlaid or glued to a solid board, why is the glue applied to the unpapered side?

CHAPTER XI

GLUING AND CLAMPING

Gluing and clamping is one of the most important phases of the woodworker's art, because the strength and appearance of the finished product is in direct proportion to the skill and accuracy with which this job has been done. Methods of clamping vary a good deal according to the work in hand, and often special blocks or fittings have to be devised.

Several kinds of glue are used commercially, of which the most important are: animal glue, liquid glue, vegetable glue, casein glue, and blood-albumen glue. These glues have different characteristics and properties which determine their use for different purposes. Animal glue has been found to be the most satisfactory for woodworking because of its strength, quick setting, stainlessness, and free-flowing consistency.

187. **Preparation of Glue.** Animal glue, as used by cabinetmakers, is either sold in sheets or flakes. Sheet glue, which is very hard and brittle, must be broken into small pieces with a hammer. The sheets should be put into a bag or cloth during the breaking-up process as the glue otherwise will be scattered all over the floor. The pieces are then put into a double-boiler glue pot, covered with water, and allowed to soak overnight. If it is a good grade of glue, the small hard pieces, when examined the following day, should have absorbed most of the water in which they were soaking. They should also have swelled to several times their original size, and be soft and jellylike. The heat of the water and steam in the outer compartment of the double boiler quickly melts the softened glue in the inner vessel.

Ordinary glue pots may be heated on a gas stove or electric hot plate. Special glue heaters are furnished with an electric heating element, which may be connected directly to an electric-light socket.

If the glue is too thick, enough water should be added to make it of the right consistency. It should run from the brush in a thin stream. The general tendency among inexperienced workers is to make the glue too thick. This prevents the pieces being glued from making proper contact, resulting in a joint that is weak and does not close properly. Boiling and repeated heatings weaken the glue.

188. **General Directions for Gluing.** (1) Have all the pieces to be glued ready so far as tool operations are concerned. Mark them plainly to show how they are to be joined.

2. Prepare blocks needed to protect the finished surfaces from being marred by clamps or hand screws. Have a few extra ones on hand.

3. Adjust all necessary clamps and hand screws to the right opening or width between jaws.

4. Place them in a convenient position together with the framing squares, try-squares, mallets, rules, or other tools necessary for the gluing job.

5. Clamp the pieces together without glue, in order to make sure that every part fits as it should and to find out the best way to apply the clamps.

6. Close all doors and windows so that no cold draft chills the glue while it is being applied. In the wintertime, it is well to warm the pieces to be glued by placing them on or near a steam radiator.

7. Apply the glue hot, and clamp the work together as quickly as possible so as to avoid chilling of the glue.

8. Test for accuracy with squares and a rule.

9. Peel off the surplus glue with a dull chisel after it has set but before it has dried hard.

It is usually advisable, and very often necessary to have one or more helpers when gluing.

189. **To Glue Two Or More Boards Edge to Edge.** (1) Joint the edges as explained in Article 139, and number the boards in the order they are to be placed.

2. Prepare four blocks, as shown in Figure 231, for the two clamps to be placed underneath the boards at each extremity.

3. Place the boards on top of these clamps, and put a third clamp on top of the boards in the center. (Fig. 232.) Tighten up the center clamp only, and see if the joints are tight all along and especially at the ends. The joints should be so tight at the ends that it is impossible to move the boards up or down by pressing on them with the hands.

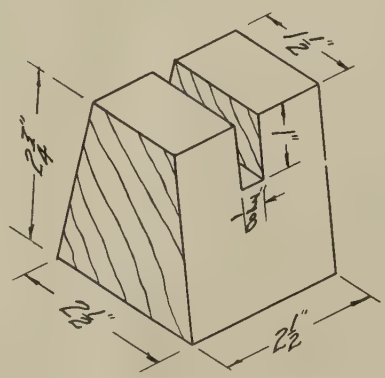


Fig. 231. Block in which to place bar clamp

4. Loosen the center clamp, and adjust the other two to the right opening.

5. Apply glue simultaneously to the two edges by holding the boards in a vertical position.

6. Tighten the center clamp on top of the boards first, and then the two underneath at either end.

7. Bring the surfaces of the boards to the same level by striking them with a mallet. This should be done after the clamps are tightened.

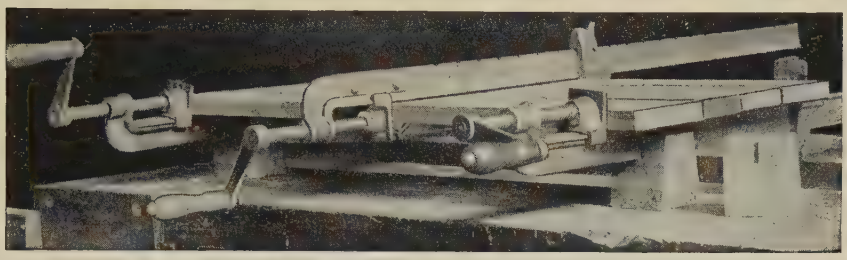


Fig. 232. Gluing boards edge to edge

8. Test for flatness with a framing square. (Fig. 233.) If the boards bulge in the center, this condition usually can be corrected by clamping them to the iron clamp below with one or two hand screws.

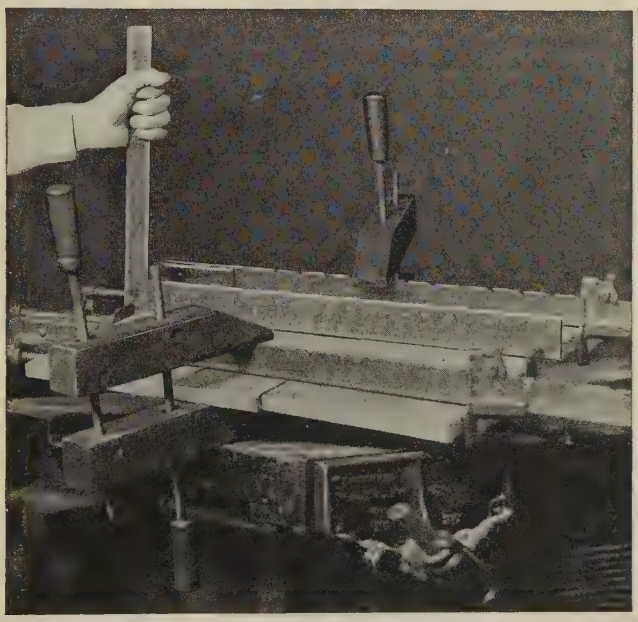


Fig. 233. Testing glued boards for flatness

9. Sight along the boards to see that they have not been sprung out of shape in the gluing process.

10. When large table tops consisting of several boards are to be

glued, it is necessary to use three or more clamps below and two or more above. Two or more heavy pieces, as 2 by 4 in., with one straight edge are also clamped across the top with hand screws so as to make it level.

11. As boards glued together to form tops must be planed after gluing, no particular care need be taken in this case to protect the surfaces or outside edges.

12. When the gluing process has been completed, the boards with the clamps attached may be lifted out of the gluing blocks (Fig. 232) and placed against a wall to dry.

190. To Glue a Frame or Panel. (1) Place two clamps in the blocks as explained in Article 189.

2. Number the mortise-and-tenon joints, and try them first without glue.

3. Apply glue both to the mortises and tenons. For the mortises a small, flat brush is needed. A small stick wrapped with a piece of waste or rag at one end may also serve the purpose. Protect finished sides by placing small blocks between them and the clamps.

4. If a panel is to be inserted between the four members of the frame, no glue should be applied either to the panel or the groove into which it fits. A panel should be free to expand or contract in accordance with the moisture it absorbs or gives off to the surrounding air.

5. Test the frame for squareness by placing a try-square in the inside corners. Correct any angles being out of square by shifting the clamps or, in extreme cases, by applying a clamp diagonally. Also test for flatness and "wind" by placing a steel square across the rails and glued points. Correct any unevenness by hand-screwing the frame to the clamps (Fig. 233), or by clamping pieces across the frame.

6. In cabinets, or stools, having two opposite sides alike, each side is glued up as explained before, after which they are clamped together with hand screws, inside faces together. (Fig. 234.) This tends to correct any twisting of legs or rails, and will insure perfectly square joints when the cabinet or stool is finally assembled.

7. Clean off the surplus glue with a chisel and waste moistened in hot water.

191. To Glue Bookshelves. (1) Finish and sandpaper the inside faces of the sides and both faces of the shelves, and try them together before applying the glue. Number all the joints.

2. Prepare short heavy blocks about 2 by 2 in. and as long as the sides are wide. Two blocks and two clamps are needed for every shelf. Each block should have one planed side. Blocks, as shown in the photograph, may also be used on small jobs.

3. Place one of the sides flat on the bench with the inside face up. Apply glue to the dadoes with a small brush and to both ends of the shelves.

4. Insert the shelves in their corresponding dadoes, apply glue to the dadoes in the other side, and place them on top of the shelf ends so that each enters in the dado cut for it.

5. Drive the joints together by striking on the upper side with a mallet, protecting the side from being marred by the blows by placing a piece of wood over each joint while it is being driven together.

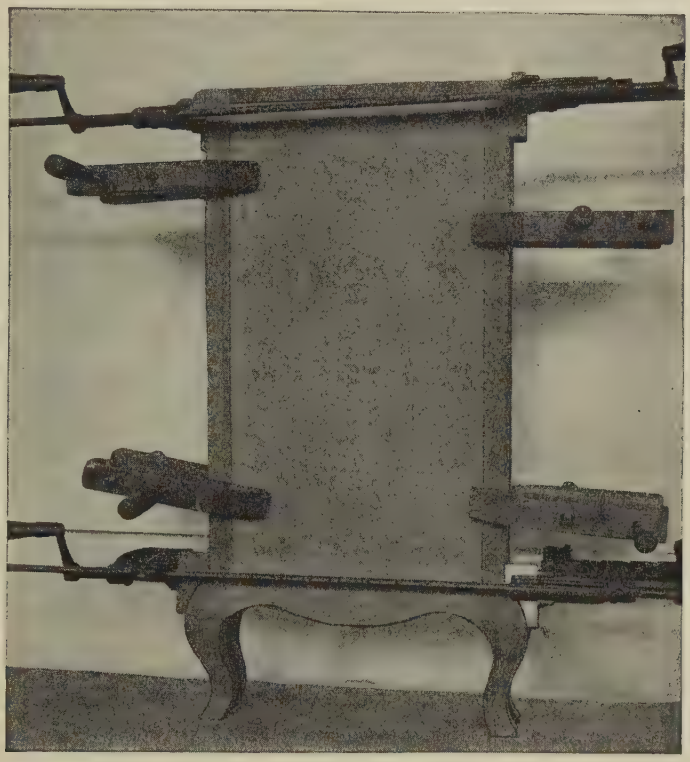


Fig. 234. Two paneled sides of a cabinet clamped and held together with hand screws

6. Place the shelves in a horizontal position, and apply the clamps. The heavy blocks extending across the sides will prevent them from bulging in the middle, which they are very likely to do when clamps are forcing the front and rear edges together, especially when the joints are tight.

7. Try for squareness by placing a try-square on both ends of each shelf. If the shelves are not quite square with the sides, this defect can easily be remedied by changing the clamps from their horizontal position to an oblique one. (Fig. 235.)

8. Peel off the surplus glue, both on the upper and lower part of the shelves, with a dull chisel after it has set but before it has dried hard. In this type of construction, glue is very likely to be smeared on the sides and shelves near the joint, and it is very difficult to remove once it has been allowed to harden.

192. **To Glue a Cabinet.** (1) Plane, scrape, and sand the two sides which were glued as explained in Article 190, and fit the back, bottom, and front rails in place. Clamp without gluing to test accuracy of construction.

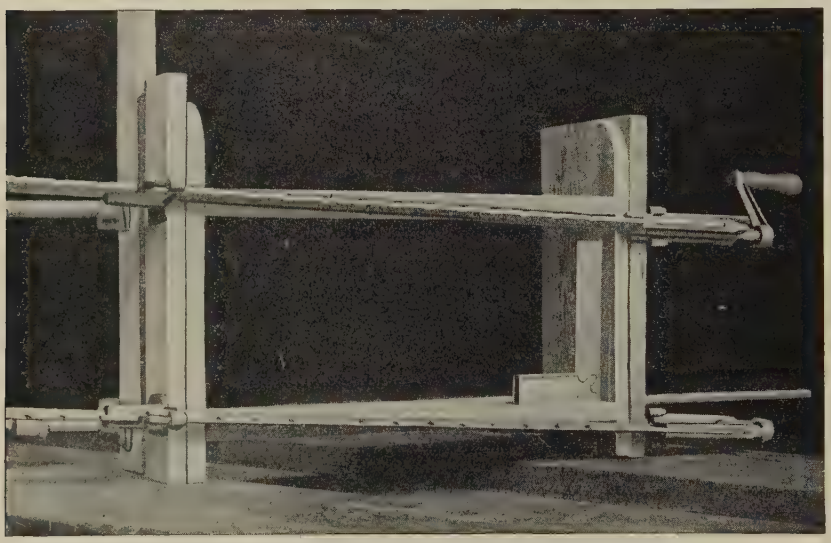


Fig. 235. Squaring bookshelf by placing clamps obliquely

2. Glue as explained before with one side flat on the bench. Place the cabinet in the natural position and apply clamps, being careful to protect the finished sides with small blocks preferably of soft wood.

3. Test for squareness with a framing square and by measuring the diagonals. (Fig. 236.) Adjust any inaccuracy by moving the clamps so that they are close against the sides at one end, and away from them at the opposite end. This is the same principle as is shown in Figure 235.

4. If the error cannot be corrected by any movement of the clamps, another clamp may be fastened diagonally on the corners having the longest diagonal, and tightened until the diagonals are even. A stick of the correct length also may be placed between the corners having the shortest diagonal.

5. Clean off the surplus glue as explained in Article 191, step 8.

193. **To Glue a Drawer.** (1) Fit the pieces together without glue,

and have clamps and blocks ready. All the inside surfaces of the drawer should be finished and sanded.

2. Glue the dovetails first, and then the rear piece.

3. Place a piece of paper over the dovetails so as to prevent the blocks from sticking to the sides. The blocks should be fairly heavy

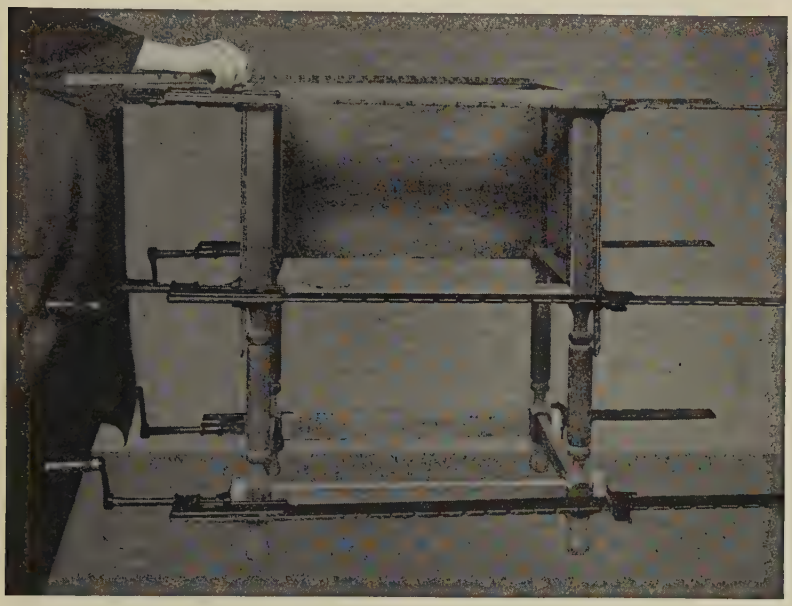


Fig. 236. Measuring diagonals

and as long as the width of the sides. One or two clamps are necessary at the front and rear, depending upon the depth of the drawer.

4. Measure the diagonals very carefully, and insert a stick if necessary as explained in Article 192.

5. Place the drawer on a flat surface to make sure it is level. If two corners are high, adjust the clamps until it is level. In extreme cases, clamp it to the flat surface, or place weights on it until all four corners touch.

6. Clean off all surplus glue, and set the drawer away to dry.

7. The bottom is slid into the groove after the glue has set. It is fastened to the underside of the rear board with brads or screws. In case of shrinkage, these can be removed and the bottom pushed farther toward the front. Some people prefer to glue the bottom to the front of the drawer.

194. To Glue a Chair. (1) Glue the back and front separately, and set them away to dry.

2. After cleaning and sanding, fit the side rails and stretchers, if any, in place.

3. Apply glue to the mortises and tenons as explained in Article 190, and clamp them together, using blocks to protect the finished surfaces from being marred by the clamps.

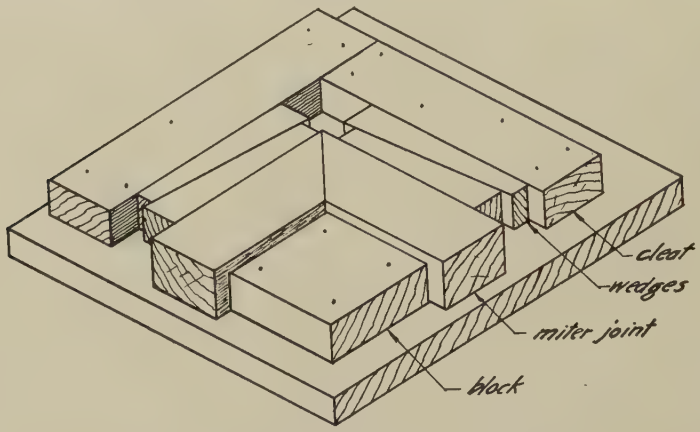


Fig. 237. Gluing a mitered joint by wedging

4. Measure the diagonals very carefully, and adjust the clamps until they are even.

5. Clean off all surplus glue, both inside and outside. Blocks are usually glued and screwed to the inside corners to strengthen the joints. (Fig. 417.)

195. To Glue Miters or Irregular Shapes. (1) A mitered picture frame, or two pieces mitered in the corner, may be glued and clamped by fastening cleats at right angles to each other to a board, and driving double wedges between the frame and two of the cleats. (Figs. 237 and 238.) Place paper between the frame and the board to prevent sticking.

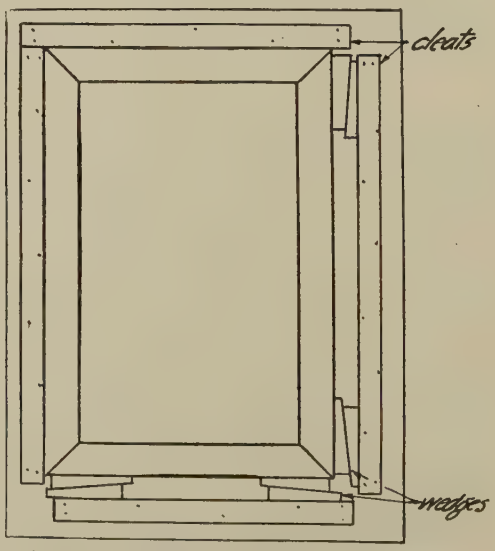


Fig. 238. Gluing a picture frame by wedging

2. A mitered joint on a chest or box may be clamped by first gluing two triangular pieces, preferably of a softer wood than

the box, to the faces near the joint. (Fig. 239.) Hand screws, clamped to these pieces, will draw the joint up very tightly. When dry, the triangular pieces are removed with a chisel, a plane, and a scraper.

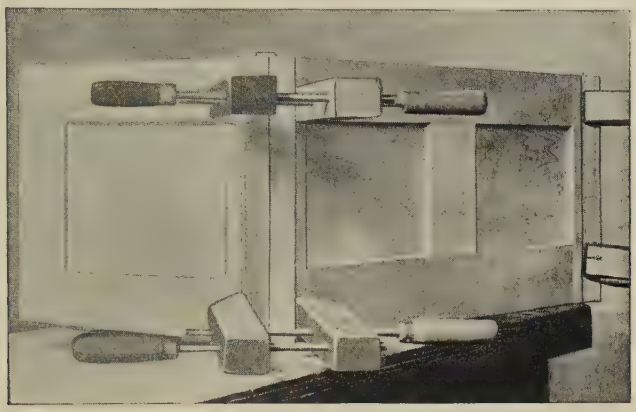


Fig. 239. Gluing a spline miter joint

3. Longer pieces with a notch cut into them for the hand screws, may also be clamped to the sides, thereby avoiding gluing.

4. Irregular shapes are glued much in the same manner, except that the blocks must be shaped to fit the curves. (Figs. 234 and 240.)

196. To Glue Doweled Joints and Segments. (1) Point all the

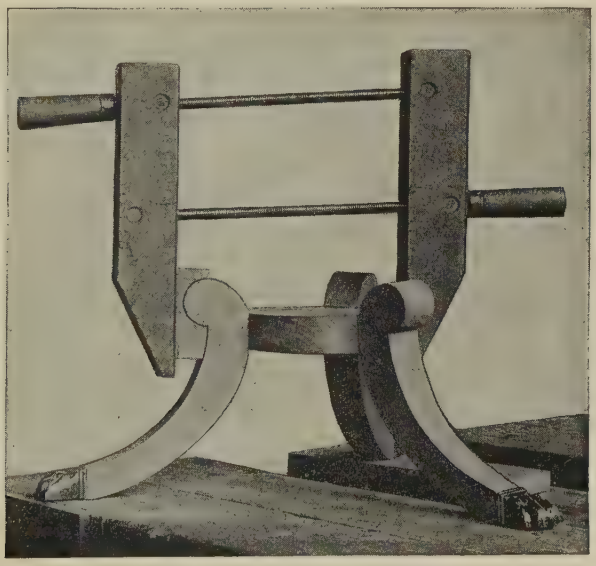


Fig. 240. Gluing irregular shape

dowels a little so that they will enter their corresponding holes easier. Also cut a small V groove along the side of each dowel so that the air and glue may escape when the dowel is driven into its hole. (Art. 156.)

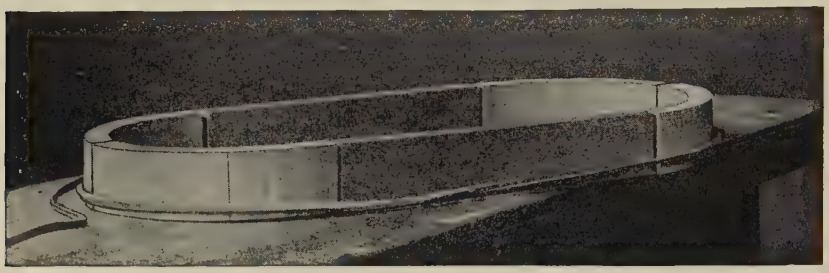


Fig. 241. Gluing segments

2. Put glue in one set of holes with a small brush or stick. Dip one end of each dowel in the glue and drive it in place with a hammer. Wipe off surplus glue with a piece of dry waste or rag. In this way the equivalent of tenons are formed.

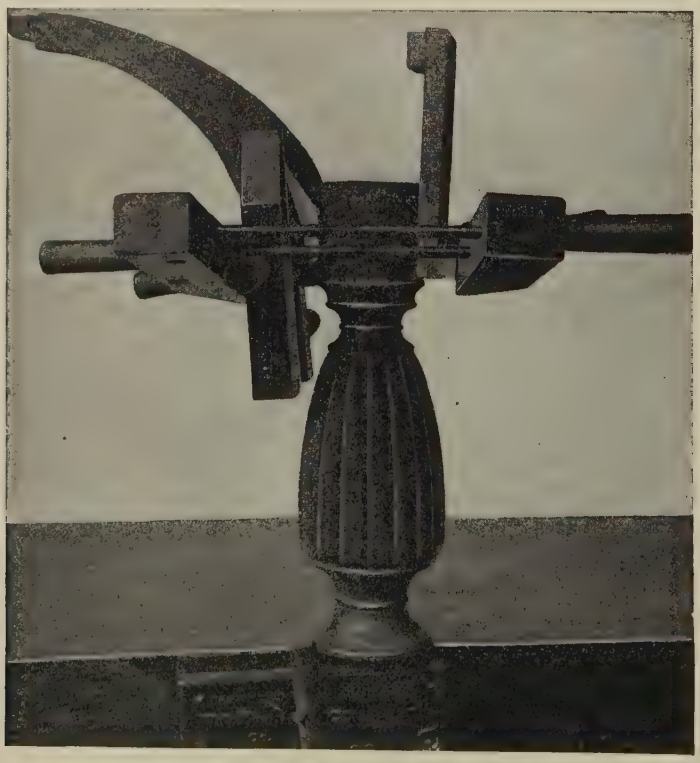


Fig. 242. Clamping leg to turned column

3. Put glue in the other set of holes, on the projecting ends of the dowels, and on the edges of the wood to be joined together.

4. Clamp as explained in Article 190, if the work is straight.

5. If segments or curved pieces are to be clamped, a strong rope or strip of leather is wound twice around the work and twisted by means of a short piece of dowel rod, until the tightening of the rope brings the joints together. (Fig. 241.) It is advisable to use sash cord, because of its strength.

Special clamps, called "column clamps" (Fig. 83), consisting of an iron chain and screw, are recommended for this type of gluing jobs.

6. Legs may be glued to a turned column by clamping a hand screw firmly to each leg near the joint. This hand screw affords a hold for two other hand screws, which force the leg tightly against the column. (Fig. 242.)

7. Glue one leg at a time, and allow it to dry before attempting to glue the next one. Fasten the column in a vise during the gluing process.

REVIEW QUESTIONS

1. Why is it important that glue should be hot and thin?
2. If three clamps are used in gluing up two boards edge to edge, which clamp should be tightened first? Why?
3. What would be likely to happen if all three clamps were placed on the same side of the boards?
4. How can any bulging of the boards in the center be corrected?
5. When should blocks be placed between the clamps and the work being glued? When may they be omitted?
6. Why should a panel never be glued into the grooves of a frame?
7. How is a square frame tested after it has been glued?
8. Give directions for gluing a footstool having four rails and four square legs.
9. What sort of gluing blocks are used for gluing a bookshelf? Why?
10. If it is found that the shelves are not square with the sides when the bookshelf is being glued, how may this be corrected while the glue is still soft?
11. Why should the surplus glue be cleaned off while it is still soft?
12. How may the squareness of a cabinet, chair, or drawer, be tested during the gluing process?
13. How is a picture frame clamped while it is being glued?
14. How may splined miter joints be clamped?
15. How is a circular table apron, consisting of four segments, glued and clamped?

CHAPTER XII

APPLICATION OF HARDWARE

After a piece of furniture has been glued up, it is necessary to fit moving parts, such as doors, leaves, drawers, etc., with different kinds of hardware. The fittings most used in cabinetmaking are hinges, locks, bolts, catches, casters, slides, pulls, knobs, and escutcheons.

198. **To Apply Screws.** Screws for wood are classified according to the material of which they are made, as steel or brass; according to the shape of their head, as flathead, roundhead, etc.; and according to their length and diameter. Screws are used for fastening most hardware fittings to the wood and also for fastening two pieces of wood together. Flathead screws of steel or brass are the ones most frequently used in cabinetmaking.

1. Bore holes for screws with a gimlet bit or a twist bit, so that the shank of the screw, which is the smooth part below the head, fits snugly, yet not so tight that it cannot be pushed into the hole easily with the fingers. In hard woods, bore also for the threaded part. This hole, of course, should be smaller in length and diameter than the threaded part of the screw. Bore holes for small screws with a bradawl.

2. When flathead screws are driven into wood, make room for the

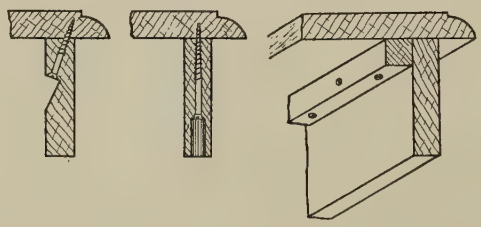


Fig. 243. Methods of fastening a table top

head of the screw so that it will come flush with the wood by countersinking; i.e., widening the top of the hole. The screw holes in the metal fastenings are already countersunk.

3. Use soap as a lubricant when driving screws. This will reduce friction and the danger of "twisting off." When a screw breaks below the surface of the wood, it is very difficult, if not impossible, to remove the part left in the hole.

4. Brass screws twist off very easily. To avoid this, drive a steel

screw of the same or slightly larger diameter first. The brass screw will then enter easily.

5. Be sure that the screw driver or screw-driver bit is of the right size for the slot in the screw, and that its sides are flat and square with the end.

199. **To Fasten a Table Top In Place.** In fastening a table top, provision should be made for the swelling or shrinkage of the wood. For this reason, whenever possible, avoid gluing. The following methods are in general use.

1. Holes are bored through the rails at an angle. The boring is done from the upper edge of the rail with a gimlet or twist bit, and a recess is cut on the inside of the rail with a gouge so as to make room for the head of the screw. (Fig. 243.)

2. A hole large enough for the head of the screw may also be bored part way through the rail with an auger bit, after which the remainder is bored with a gimlet or twist bit and the screw inserted. (Fig. 243.)

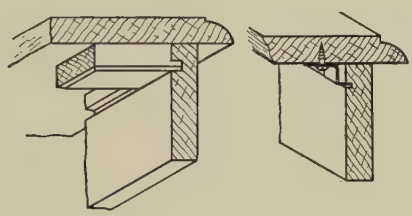


Fig. 244. Methods of fastening a table top

Strips of wood about ¾ to ⅞ in. square are screwed to the inside of the rails, flush with their upper edge. (Fig. 243.) The top is placed face down on the bench. It is well to protect it from being marred by placing two cleats between it and the bench top. The frame of the table is now placed on the top. The distance from the rails to the edges of the top is then measured, after which the frame is fastened to the top with screws driven through holes previously bored and countersunk in the strips. These holes should be large enough to permit the screws to move slightly when the top shrinks and swells.

4. A groove is cut on the inside of the rails before they are glued to the legs. Wooden blocks, rabbeted on the end so that they fit into the groove, are then screwed to the top at intervals. (Fig. 244.) This method permits of considerable movement of the top.

5. A modification of the wooden block is the table-top fastener, which is a small piece of iron bent at right angles. One end fits into a slit cut on the inside of the rails with a circular saw, and the other end is screwed to the top. (Fig. 244.)

200. **To Fasten Hinges.** Hinges are made in a great variety of shapes for many different purposes. The most common hinge for

cabinetwork is the butt hinge, either with fast joint (Fig. 245), or loose pin (Fig. 246). The best kind are made of brass, and they are classified according to length and width of leaves. Other hinges used in cabinetwork are: The invisible hinge (Fig. 247), pivot

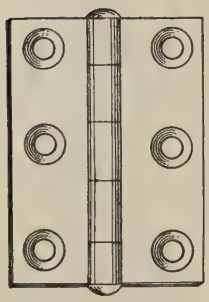


Fig. 245. Fast-joint butt hinge

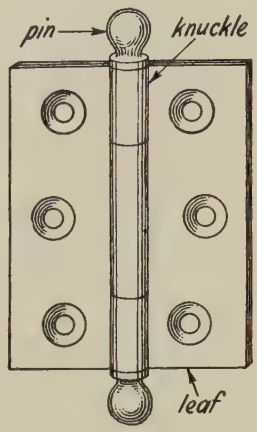


Fig. 246. Butt hinge with loose pin

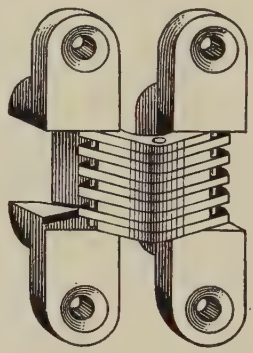


Fig. 247. Invisible hinge

hinge, chest hinge (Fig. 248), desk hinge, card-table hinge, double-acting or screen hinge (Fig. 249), etc.

When hinging a paneled door, it is the custom to place the hinges so that the upper one is placed just below the upper rail and the lower one just above the lower rail. (Fig. 250.) When hinging the lid of a

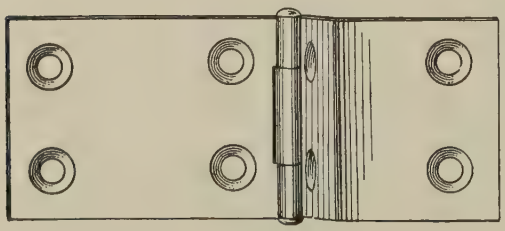


Fig. 248. Chest hinge

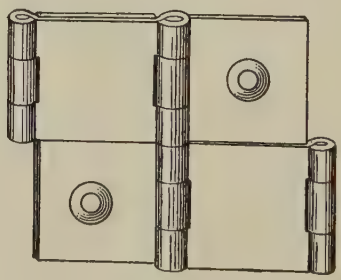


Fig. 249. Double-acting hinge

box or chest, the hinges should be placed so that the distance from the hinges to the end of the box is equal to the length of the hinge.

1. When hinging a door, place it in its opening so that its upper edge is tight against the frame. This may be done by driving wedges

under it. Mark the position of the hinges both on the door and on the frame. (Fig. 250.)

2. Remove the door, and square lines across its edge from the points marked on its face. Do likewise on the frame.

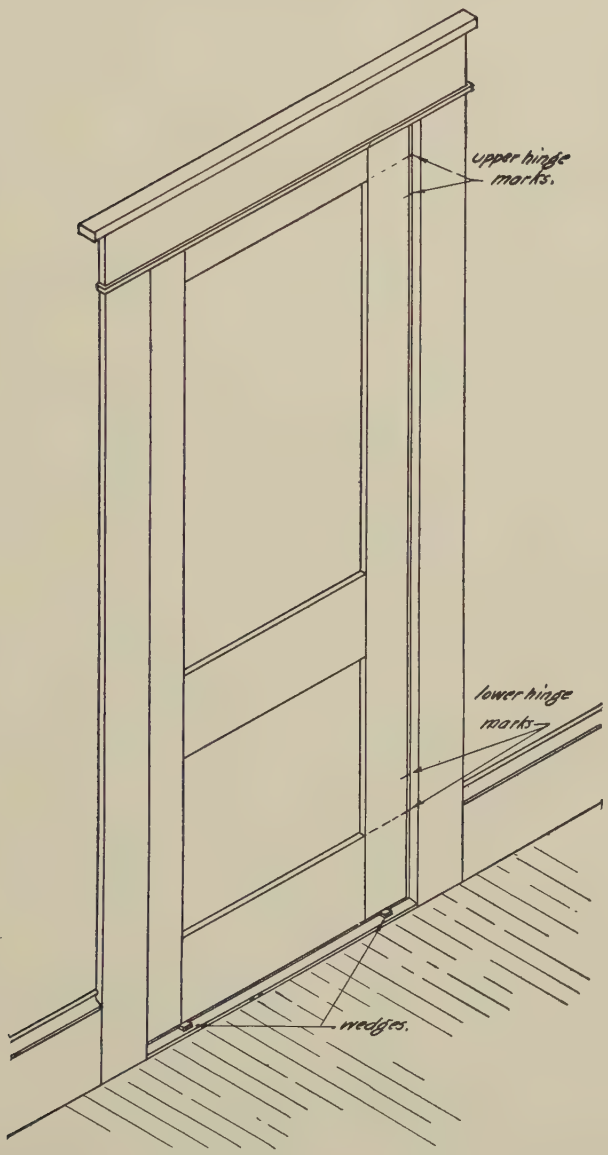


Fig. 250. Marking position of hinges on a door and frame

3. Set the butt gauge equal to the width of the leaves, not including the knuckle, which should project beyond the face of the door and frame in order to permit the door to swing freely. Mark the width on both door and frame.

4. When hinging a cabinet door, set the butt gauge to half the thickness of the "knuckle," and mark lines on the face of the door and frame. On larger doors, only the thickness of the leaf is marked.

5. Chisel the outline or "gain" of the hinge very carefully, making a small V cut on the inside of the lines marked.

6. Make a series of shallow chisel cuts within the V cut, and remove the surplus wood by chiseling carefully across the grain with the bevel side of the chisel up. (Fig. 251.)

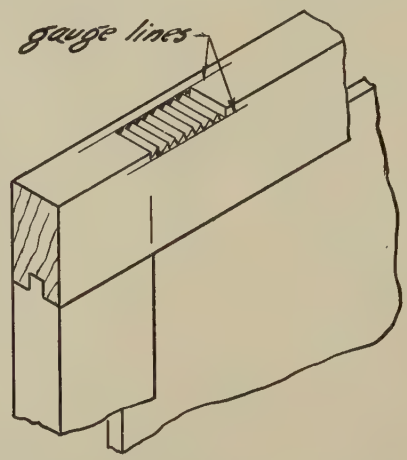


Fig. 251. Chiseling "gain" on door

7. The recess may be finished with a router plane.

8. Place the hinges in position, and bore for the screws with a bradawl. (Art. 198.) If a loose-pin hinge is used, take the hinge apart and screw each part to the door and frame respectively. Place the door in position, and insert the pin.

9. If there is a crack between the edge of the door and the frame, the recesses or gains cut for the hinges are not deep enough. If the edge of the door and frame come too close together, so that the door springs back when an attempt is made to close it, the gains are too deep. This defect can be rectified by removing the hinges, and placing a piece of heavy paper in the gain or recess.

10. When the hinges are not to be seen, it is desirable to use invisible hinges. (Fig. 247.) These hinges are mortised into the door and frame, and are not difficult to apply. They have rounded edges that fit the curve made by the proper size auger bit.

201. To Attach Locks. Cabinet locks are used for doors, drawers, chests, desks, or boxes. Locks for doors and drawers have a plain bolt, while chest, desk, or box locks have a bolt provided with a hook. Locks used in the best cabinetwork are either mortise locks (Fig. 252), or rim locks. (Fig. 253.) The first kind, as the name implies, is mortised into the wood so that only the selvage shows. The second kind is fastened on the edge of the wood, so that both the selvage and the back of the lock show. Cylinder locks are more suitable for office furniture, but rather unsightly on cabinet doors and drawers.

Sizes of locks are indicated by the length and width of the selvage and the lock box, and also by the distance from the selvage to the key pin. (Figs. 252 and 253.)

Key pins are located on the vertical center line of drawers and a little above the horizontal center line on doors.

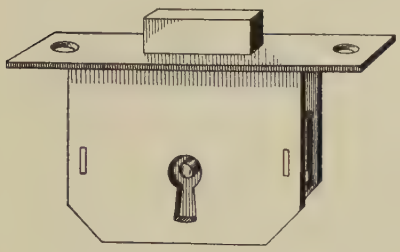


Fig. 252. Mortise lock

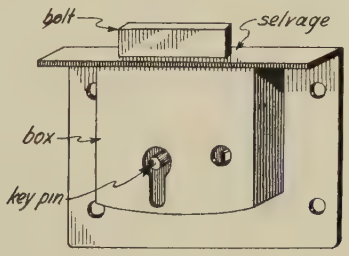


Fig. 253. Rim lock

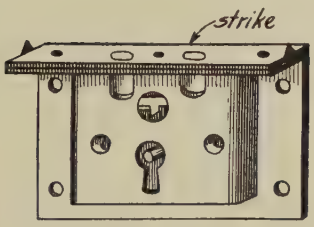


Fig. 254. Chest lock

Most locks are provided with a strike (Fig. 254); i.e., a metal plate which is screwed to the frame directly opposite the lock, so that the bolt, when in locked position, enters the opening in the strike provided for it.

1. Measure the distance from the selvage to the key pin, and lay it off on the center line or above the center line as the case may be. Bore a hole slightly larger in diameter than the barrel of the key. *Note that the key pin is not always in the center of the lock box.* (Fig. 253.)

2. If a mortise lock is used, bore and chisel the mortise for the lock box in the center or toward the rear edge of the wood, so that sufficient material remains in front of the lock on which to fasten the escutcheon.

3. Place the lock in the mortise, and mark around the edges of the selvage. Remove the lock and chisel the recess for the selvage. (Fig. 251.) Bore for screws with a bradawl, and screw the lock in position.

4. Finish the keyhole with a keyhole saw or coping saw. (Fig. 34.)

5. The procedure in fastening a rim lock is the same as for a mortise lock, except that the recess for the lock is chiseled on the inside edge of the drawer or door.

6. The strikes for chest, desk, or box locks are always provided with little points on the reverse side which help in locating their position. (Fig. 254.) Place the strike over the lock, and lock it. Close the lid, and press or pound on it with the hand. The marks of the points can then be seen, and the strike easily located.

7. The position of the strikes for drawer or door locks can be located as follows. Turn the key so that the bolt is in the locked posi-

tion. Put a little white paint or other coloring material on the edge of the bolt. Turn the key so that the bolt is again drawn into the lock.

Close the door or drawer, and turn the key a few times as if to lock it. Some of the coloring material on the edge of the bolt will then be transferred to the frame, so that it will be easy to locate the strike.

Escutcheons or key plates usually are fastened over the keyhole with brass pins. (Fig. 255.) When thread escutcheons (Fig. 256) are to be used, the keyhole must be enlarged. They should fit very tightly, or they will come loose.

Fig. 255. Escutcheon

Fig. 256. Thread Escutcheon

FASTENING CATCHES AND BOLTS

Catches and bolts are locking devices of a more informal nature than locks. They are used in such places as the left-hand door of double doors, tilt-top tables, or small single or double doors which need not be

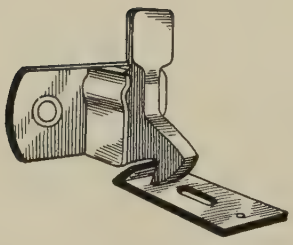


Fig. 257. Elbow catch

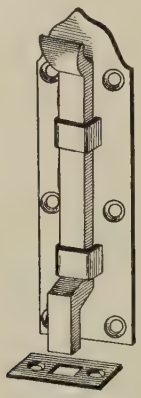


Fig. 258. Door bolt

Fig. 259. Flush bolt

locked with a key. The following are the most commonly used bolts and catches in cabinetwork.

202. **Elbow catches** (Fig. 257) may be used on left-hand cupboard or bookcase doors. The plate is simply screwed to the upper side of the center shelf, and the catch to the inside of the left-hand door.

203. **Door bolts** (Fig. 258) are screwed to the inside of left-hand bookcase doors near the top and bottom of the door, so that the bolt locks into the frame around the doors. Sometimes only one bolt is used

on a door. Door bolts are sometimes fitted with a steel spring, which automatically keeps the bolt in the locked position. They are usually furnished with a strike plate. A hole must be chiseled or bored in the frame for the bolt.

204. **A flush bolt** (Fig. 259) is the neatest type of door bolt. It is fastened to the edge of the left-hand door and must be set flush with the

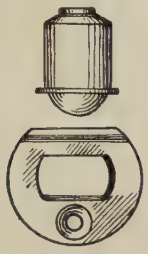


Fig. 260.
Ball catch

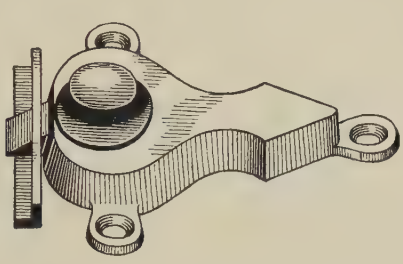


Fig. 261. Table catch

wood. Flush bolts are sold in different widths according to the thickness of the wood. The strike plate is set flush with the doorframe, and a hole is bored for the bolt.

205. **Ball catches** (Fig. 260) or friction catches consist of small brass cylinders with a steel spring bearing against a steel ball. They are used on small doors such as those on a phonograph or a radio cabinet, and are usually fitted into the upper or lower edges of the door. They are manufactured in diameters of $\frac{1}{4}$, $\frac{5}{16}$, and $\frac{3}{8}$ in., and all that is necessary to do to attach them is to bore a hole of the proper diameter in the edge of the door. The strike, which is beveled on one edge, is set into the frame flush with the wood. The beveled side should be placed toward the front.

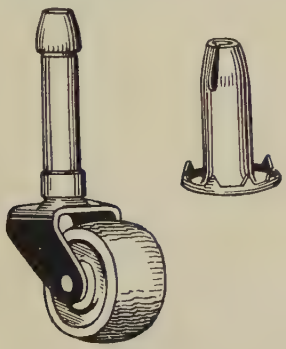


Fig. 262. Caster

206. **A table catch** (Fig. 261) is in reality a small spring lock, the bolt of which is moved in or out by means of a spring and a knob. A table catch is used for locking the top of a tilt-top table in a horizontal position. It is screwed to the underside of the table top. The strike plate is fastened to the wooden block to which the top is hinged. It is set flush with the wood and a recess chiseled for the bolt. (Fig. 395.)

ATTACHING CASTERS, GLIDES, AND CHAIR TIPS

207. **Casters** are used on heavy pieces of furniture to make them more mobile. They are generally made with a stem and a socket. The

socket has a ring of teeth at its lower extremity, while its upper end is slit for a short distance and pressed to a smaller diameter. The wheels of casters are made of steel, brass, wood, fiber, rubber, or felt. (Fig. 262.)

To attach the caster, bore a hole in the end of the leg so that the socket fits snugly, but not tight enough to split the wood when the socket is driven in place. The ring of teeth must be driven into the end wood. The stem of the caster has a little projection on the upper

Fig. 263. Brass socket

Fig. 264. Glide

Fig. 265. Chair tip

end. A tap with a hammer will force it through the narrow end of the socket, which will again spring together and prevent the stem from slipping out.

Some casters are provided with a brass socket (Fig. 263) which fits over the end of the leg. Caster rings and sockets may also be bought separately and fitted over legs of furniture. They are made both square and round, and furnished in various sizes. They are decorative and prevent the wood from splitting.

208. Glides are hardened, polished, cup-formed pieces of steel used instead of casters. (Fig. 264.) They are provided with steel points and are fastened to the legs of furniture simply by driving them into the wood with a hammer.

209. Chair tips (Fig. 265) are similar to glides except that they are made of soft material, such as rubber, felt, or leather. They are attached to chair legs either by screws, nails, or steel points.

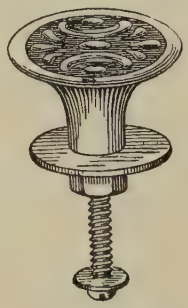


Fig. 266. Furniture knob

210. To Attach Furniture Pulls and Knobs. Furniture pulls and knobs are made in a great variety of patterns to conform to the furniture designs of the different historical periods. They are fitted with machine screws about $\frac{3}{16}$ in. in diameter and 1 in. long which screw into holes, bored and tapped in the pull itself. These screws have a round, slotted head with a small washer soldered to it. (Fig. 266.)

After locating their position on a drawer or door, as the case may be, bore holes of the same diameter as the screw right through the wood. Place the pull in position, insert the screws from the inside of the door or drawer, and tighten them with a screw driver.

No definite rules can be given for the location of pulls and knobs, except that they are always placed on the horizontal center line of drawers, and usually above the center of a cabinet door. On a chest of drawers, one is placed directly below the other; i.e., the same distance from the ends of the drawer.

REVIEW QUESTIONS

1. What precautions should be taken to prevent a screw from "twisting off"?
2. Why is a screw driver with flat sides and sharp edges at the end more efficient than one with rounded edges?
3. Why should a table top not be fastened by gluing?
4. Describe three methods of fastening a table top.
5. What are the rules for placing hinges on a paneled door?
6. What rules should be followed in locating hinges on a box?
7. Why is the upper edge of a door forced tightly against the frame when marking the position of the hinges?
8. How should the "gain" for a hinge be chiseled?
9. If the "gains" are chiseled too deeply, how may this effect be corrected?
10. State the difference between mortise locks, rim locks, and cylinder locks.
11. A $\frac{1}{16}$-in. satinwood band is inlaid on the face of a drawer, $\frac{5}{8}$ in. from its edges. What should be the least distance from the selvage to the key pin on a mortise lock for this drawer?
12. State the difference between door bolts and flush bolts; between elbow catches, ball catches, and table catches.
13. What is the purpose in using caster rings and sockets?
14. What is the difference between glides and chair tips?
15. How are furniture pulls and knobs fastened?

CHAPTER XIII

WOOD TURNING

212. **History.** Wood turning is one of the oldest trades on record. However, it is fast disappearing through the use of modern machinery designed for quantity production. Wood turning probably originated in Egypt and was brought from there to the East, to ancient Greece, and to Rome. Among all the trades, it is unique in that it was practiced during the seventeenth century by kings and princes, and even by queens and ladies of high rank. These men and women took great pride in their craftsmanship, and examples of this royal handwork are to be found in many European museums.

Wood turning is done by two distinct methods, the *cutting* method and the *scraping* method. The cutting method is used by professional wood turners and is preferred by cabinetmakers. It is faster and cleaner than the scraping method, requiring very little sanding, but it is more difficult to learn, and requires considerable practice.

The scraping method is easier to learn and is safer for the inexperienced workman. It is recommended for those who merely take up wood turning as an aid to cabinetmaking so as to enable them to make furniture with turned parts. The following instructions are written mainly for this class of people, and are therefore necessarily brief. Patternmakers, when making patterns having turned parts, also use the scraping method.

For those who work without the counsel and guidance of a teacher, the scraping method is also preferable, because it is easier to understand from written instructions.

213. **The Lathe and Its Parts.** To our eyes, the earlier lathes and tools seem rather crude affairs. In some, the work was revolved by means of a treadle, and in others, only a string wound around the work to be turned served as a means of propulsion. Recent inventions and modern methods of manufacturing have completely revolutionized these primitive methods. Power-driven lathes for every purpose can now be had quite cheaply; indeed many machinery houses make a specialty of manufacturing small lathes and other woodworking machinery for smaller shops, schools, and amateur woodworkers. (Fig. 90.) Figure 267 shows a drawing of a modern wood-turning lathe made entirely of iron. It consists of the following major parts: the bed and shears, the legs, the headstock, the tailstock, and the toolrest.

214. **The bed** is the main part of the lathe. Its upper part, called the "ways or shears," is machined. It is supported on the legs, which

are bolted to its underside. The headstock is bolted to its left-hand end, and the tailstock and toolrest can be clamped to it at any point between the headstock and the right-hand end.

215. The headstock consists of a cone pulley, which is fastened to a hollow spindle. This spindle runs in two bearings. One end of it is threaded to receive chucks and faceplates. The live center, which has a central point and two or four prongs, is tapered to fit the hollow spindle. It can be removed by driving on it with an iron rod, a part of the lathe equipment, which is inserted from the left. The height of the live center over the bed indicates the "swing" of the lathe; i.e., the diameter of stock, which can be turned in the lathe. If it is 6 in. above the bed, the lathe is said to have a "swing" of 12 in., because stock up to 12 in. diameter can be turned in the lathe.

216. A Countershaft consisting of a similar cone pulley and a tight and loose pulley is used with this type of headstock. It usually is fast-

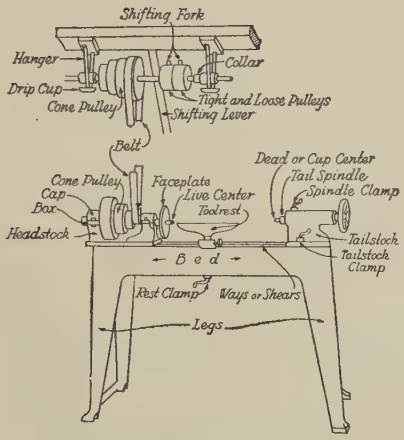


Fig. 267. Wood-turning lathe with countershaft overhead

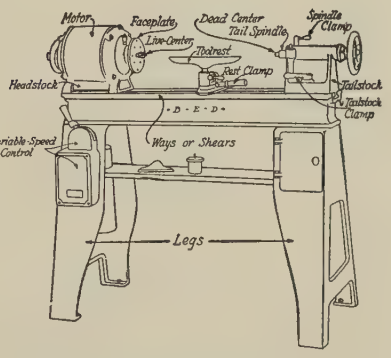


Fig. 267*a*. Wood-turning lathe with motor-head block

ened to the ceiling above the lathe. A small motor drives the countershaft, and this in turn drives the lathe. The belt from the pulley on the motor runs on the loose pulley of the countershaft. To start the lathe, move over the belt-shifting device, which usually consists of an iron fork to which a wooden handle is fastened, so that the belt is made to run on the tight pulley. This starts the countershaft revolving, and its motion is transmitted to the lathe by means of a belt connecting its cone pulley with that on the headstock of the lathe. Similarly, the lathe may be stopped for short periods without stopping the motor, merely by shifting the belt back to the loose pulley.

Sometimes a special motor, having a cone pulley, is furnished with the lathe. In such cases, it is generally fastened to the legs below the headstock, and thus eliminates the somewhat cumbersome countershaft.

The most modern type of headstock, however, is the so-called motor head; i.e., a motor, which not only drives the lathe, but also takes the place of the cone pulley and countershaft. Such motors always have variable speeds.

217. **The tailstock** consists of a casting, which can be clamped to the lathe bed by means of a lever at any point between the headstock and the end of the bed. It contains the dead center, which, like the live center, fits into a hollow spindle. This spindle can be moved in a horizontal direction by means of a screw, which is turned by the handwheel at the right. When it is desired to remove the dead center, the spindle is moved into the tailstock until the end of the dead center comes in contact with the internal screw and can go no farther. Continued turning of the handwheel moves the spindle farther to the right, and the dead center is pushed out. The spindle may be clamped in any desired position by means of a lever.

218. **The toolrest**, like the tailstock, may be clamped at any point on the lathe bed. It consists of a socket which holds the T rest. The turning tools are held directly on the T rest, which can be moved up or down in the socket and fastened by means of a lever at any point.

219. **Chucks and faceplates**, which are furnished with the lathe, are devices used for holding work in the lathe when the dead center is not used as a support. They are threaded to screw on to the end of the headstock spindle after the live center has been removed.

220. **The Speed of a Lathe.** A lathe should run at a speed of about 2500 r.p.m. when the belt is on the smallest step of the cone pulley; i.e., the part nearest to the live center. If it is necessary to buy new pulleys when installing a lathe, the diameter of such pulleys can easily be calculated, when it is remembered that the diameter of the driven pulley times the number of revolutions it makes is always equal to the diameter of the driving pulley times the number of revolutions it makes.

To illustrate with a practical example: A man buys a lathe with its corresponding countershaft. The cone pulleys have three steps, the smallest being 3 in. in diameter and the largest 9 in. in diameter. The tight and loose pulleys measure 6 in. in diameter. He already has a ¼-h.p. motor with a speed of 1200 r.p.m. The motor is equipped with a pulley 4 in. in diameter. Will this motor drive the lathe at the proper speed?

It is first necessary to find the speed at which the countershaft will revolve when it is belted to the motor.

Solution:

Revolution of motor	×	diameter of pulley	=	revolution of countershaft	×	diameter of loose pulley
1200	×	4	=	revolution of countershaft	×	6
	4800		=	800	×	6
	4800		=		4800	

The countershaft makes 800 r.p.m., and therefore the cone pulley on the countershaft also makes 800 r.p.m. The problem now is to find how many revolutions the spindle of the lathe makes.

Revolution of countershaft × diameter of large cone pulley = Revolution of live spindle × diameter of small cone pulley

800 × 9 = Revolution of live spindle × 3

7200 = 2400 × 3

7200 = 7200

Stock not more than 3 in. in diameter can be turned at the highest speed of the lathe, or 2500 r.p.m.; stock from 3 to 6 in. in diameter should be turned at a medium speed with the belt on the second step of the cone pulley; and stock over 6 in. in diameter should be turned at the slowest speed of the lathe. Before the stock is rounded off and runs true in the lathe, it causes a great deal of vibration. The lathe should, therefore, be run at a slower speed until this process has been completed, as excessive speed may cause the stock to be thrown from the lathe. This, of course, is dangerous both to the operator and to those who may be nearby.

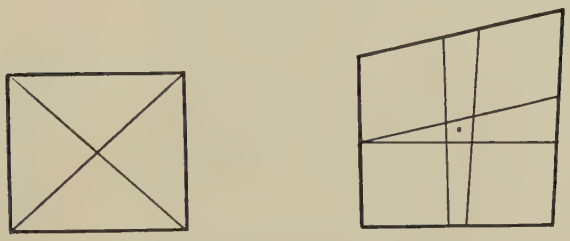


Fig. 268. Finding centers of square and irregular-shaped stock

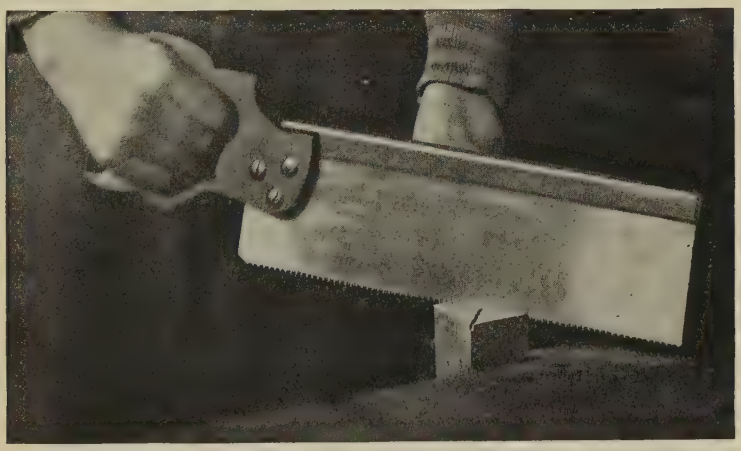


Fig. 269. Sawing on diagonals

221. To Center and Clamp Stock in the Lathe. (1) Saw the stock to dimensions, having the ends square to the sides.

2. On square or rectangular stock, draw diagonals on both ends. The center of the piece lies in the point of intersection.

On irregularly shaped stock, the center may be found as follows:

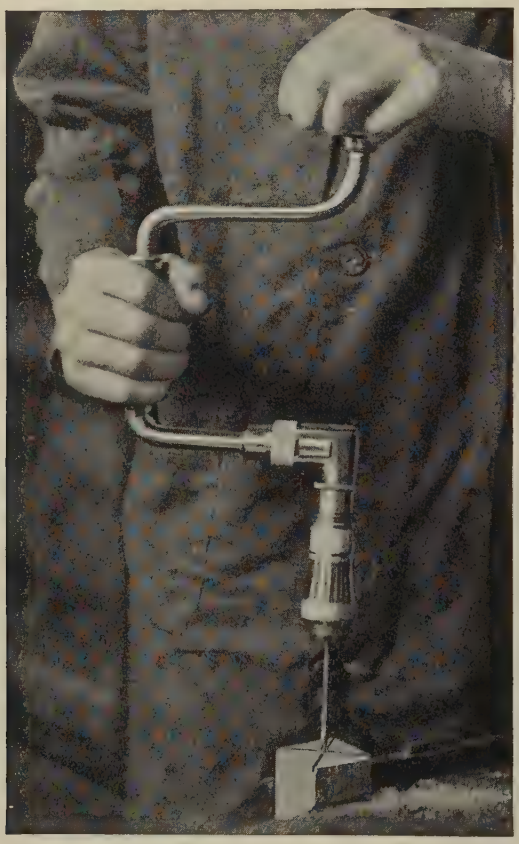


Fig. 270. Boring for centers

Set a pair of dividers to approximately half the thickness of the piece. Hold one of the legs of the divider against one of the edges, and scratch a line parallel to it. Repeat on the other three edges. The center is now readily determined. (Fig. 268.)

3. If the lumber is hard, it is well to make a saw cut on the two diagonals on one end (Fig. 269), and to bore a small hole in the center of the other end (Fig. 270), so that the live and dead centers may enter the wood more readily.

4. Remove the live center from the headstock of the lathe by pushing it out with an iron rod, which can be inserted from the opposite end of the headstock. This rod is part of the regular equipment of the lathe, and is usually found hanging on a lug on one of the legs.

5. Drive the live center into that end of the wood on which the diagonals were sawed, so that the prongs enter a saw cut. *Use a mallet* when hammering on the center. (Fig. 271.) Do not drive the wood

Fig. 271. Driving live center into end of stock

onto the live center while it is in the lathe, as the blows of the hammer are injurious to the bearings.

6. Drip machine oil on the other end of the wood, holding it in a vertical position, and allowing the oil to soak in.

7. Replace the live center in the headstock, press the wood to be turned against it, and move the tailstock so that the point of the dead center is a couple of inches away from the end of the wood. Clamp the tailstock firmly to the lathe bed, and turn the handwheel so

that the dead center enters the end wood so deeply that the wood cannot be revolved by hand. Loosen the handwheel a little, until the wood can be revolved quite freely by hand. Clamp the dead center in this position.

8. Adjust the toolrest, so that it is about ⅛ in. away from the edge

Fig. 272. Cutting with gouge

that is nearest to it when the wood is revolved. Clamp it firmly to the lathe bed. Also adjust it to the correct height. This varies somewhat with the height of the person, but is *never below the center of the piece.* It is generally from ⅛ to ¼ in. above the center.

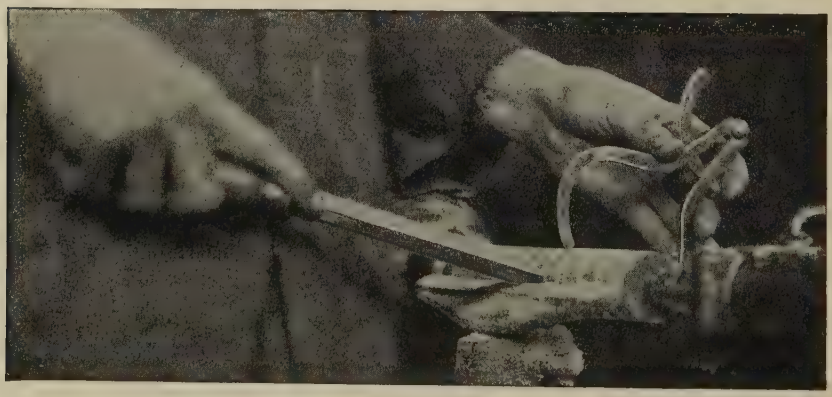


Fig. 273. Cutting to size with parting tool

9. Revolve the wood by hand to make sure that it has sufficient clearance. See that all the clamps are tight and that no tools are in the way.

222. To Turn a Plain Cylinder. (1) Start the lathe so that the stock does not revolve too fast causing the lathe to vibrate, which it is very likely to do before the stock has been rounded off. Excessive speed may even cause it to fly out of the lathe and injure someone.

2. Use the gouge for the first cut. Grasp the handle near the end with the right hand. The blade is held firmly against the T rest with

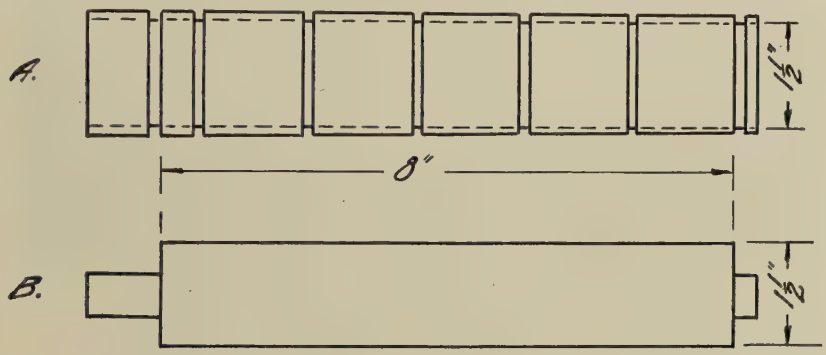


Fig. 274. Method of turning plain cylinder. (*A*) Rough cylinder sized with parting tool; (*B*) Finished cylinder

the left hand, so that the palm of the hand near the wrist and the little finger is in contact with the T rest. (Fig. 272.) Hold the handle well down and roll the gouge a little toward the right. This will throw the shavings away from you. Some turners hold the gouge in the manner

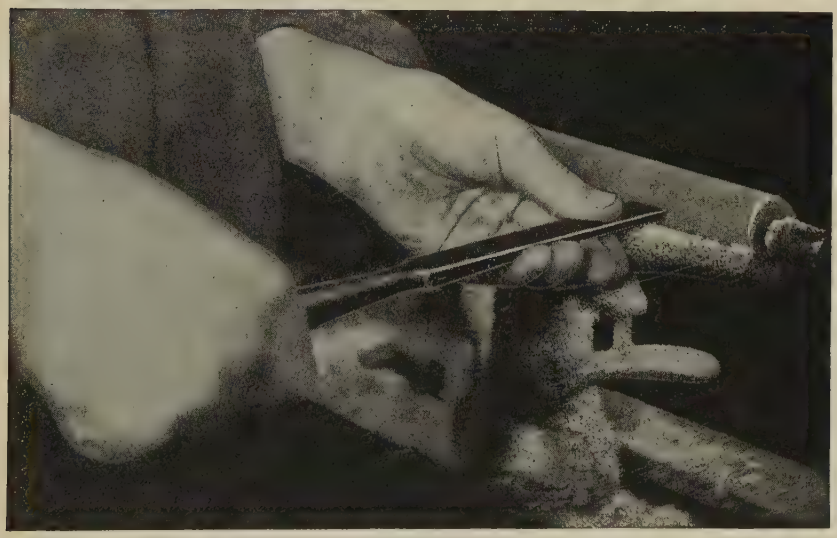


Fig. 275. Smoothing with square-nose chisel

illustrated in Figure 285. It is claimed that this method is faster and allows greater freedom of movement.

3. Start cutting a couple of inches from the dead center, moving the

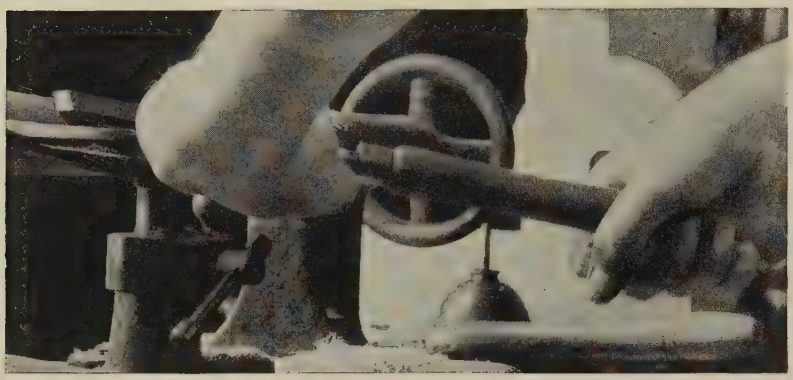


Fig. 276, Smoothing with a large skew chisel

gouge away from you toward the dead center. Then start the next cut a couple of inches farther to the left, and so on until only an inch or so is left. Roll the gouge toward you, and move it toward the live center to round off the last part of the stock. When too long a cut is

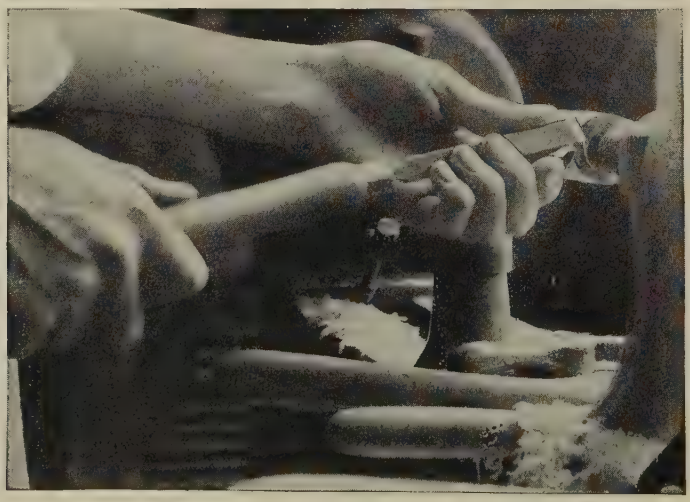


Fig. 277, Squaring end with skew chisel

taken while rounding off the corners, large chips are likely to fly off and injure the operator.

4. Move the gouge freely from one end of the piece to another until

it is perfectly cylindrical and a little larger in size than actually needed.

5. Move the T rest closer to the wood being turned.

6. Set the outside calipers to about $\frac{1}{32}$ in. more than the finished diameter of the piece. Grasp the parting tool in the right hand and the calipers in the left. (Fig. 273.) Cut into the wood with the parting

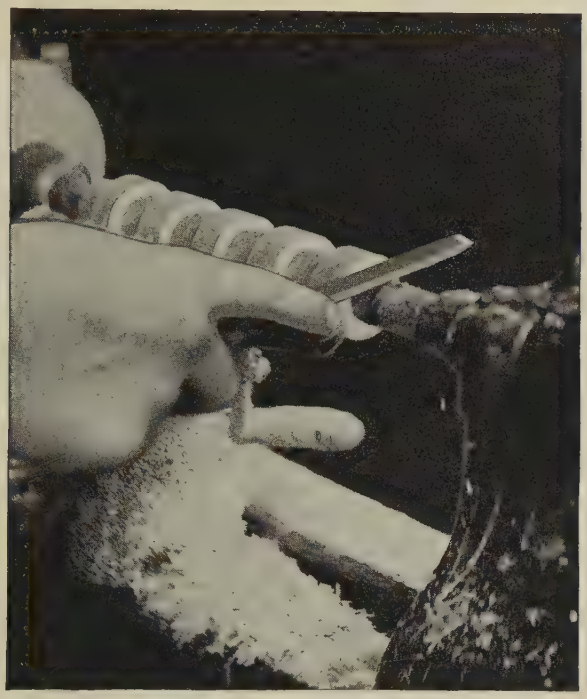


Fig. 279. Testing for squareness with side of chisel

tool while holding the calipers in the groove being cut until the caliper slips over the cylinder. Make several cuts about 1 in. apart with the parting tool. (Fig. 273.)

7*a*. Smooth the cylinder with a turning chisel, square-nose or ordinary firmer chisel with a long blade (scraping method). Hold the beveled side down, and place the chisel flat on the T rest. (Fig. 275.) Cut down to the bottom of the grooves made with the parting tool, until the cylinder is smooth and of the same diameter throughout.

7b. Wood turners smooth the cylinder with a large skew chisel. The chisel is held at an angle of about 60 deg. to the surface, and can

be moved either to left or right. Never start the cut at the end. The chisel should cut about ⅜ in. from the heel. (Fig. 276.)

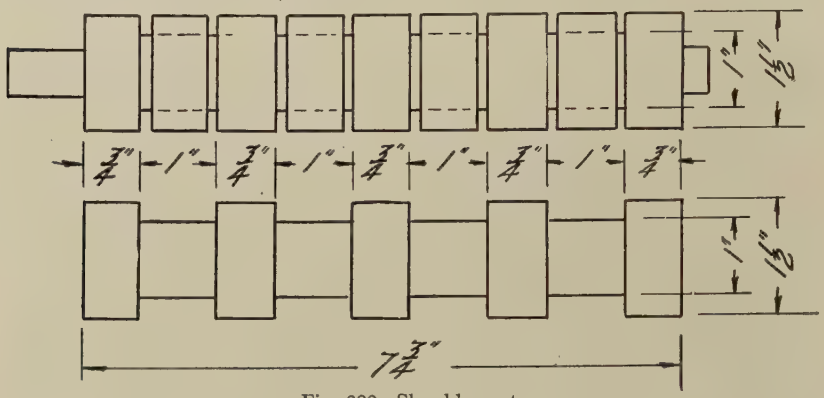


Fig. 280. Shoulder cuts

8. Square the end running on the dead center with the skew chisel. Hold the chisel so that the bevel is parallel to the end. Start the cut with the toe or pointed end of the chisel. Raising the handle forces the chisel into the stock. (Fig. 277.) Test it by placing a try-square or other straightedge across its end. If the hole left by the dead center will be unsightly, this cut should be made about ½ in. from the end.

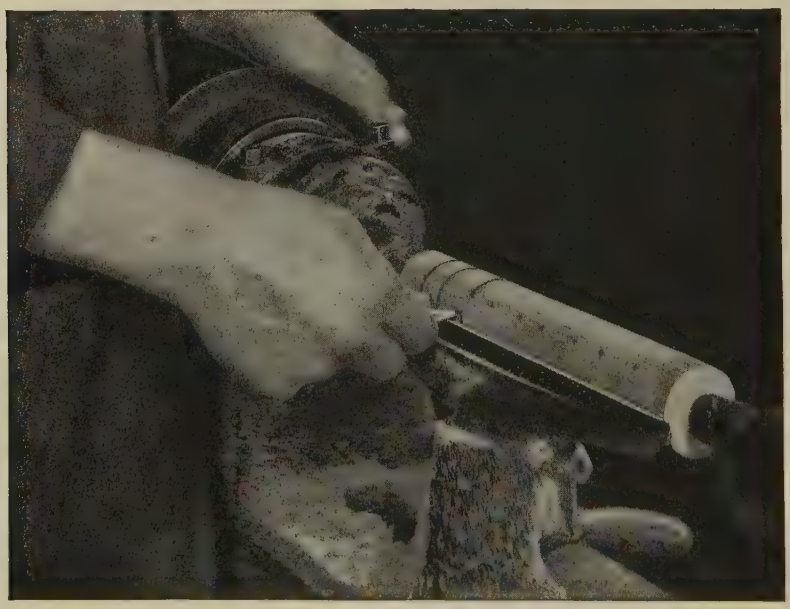


Fig. 281. Laying out dimensions with a pencil

Cut down with a parting tool to about 5/8 in. diameter. Test for squareness by holding the side of the tool against the end. (Fig. 279.)

Fig. 282. Cutting between shoulders with a gouge

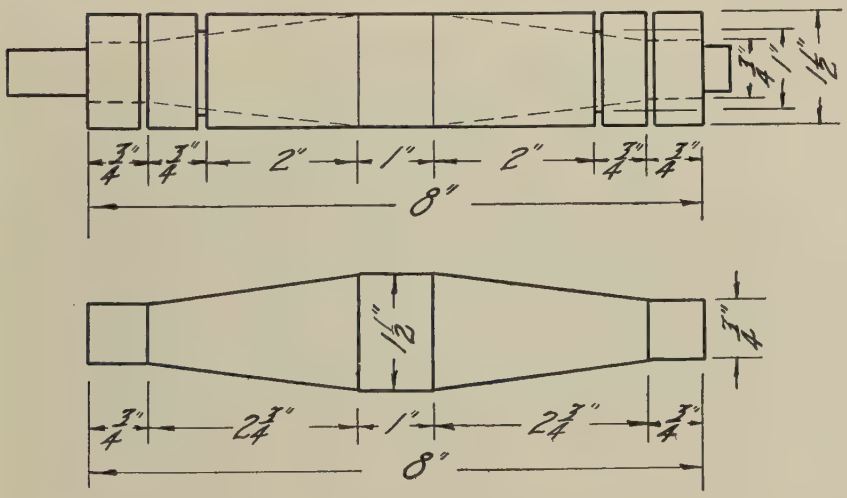


Fig. 283. Taper cuts

Measure the length, and make a similar cut on the other end. Reduce the diameter of the waste piece a little, but be careful not to cut too near the live center.

223. To Make Shoulder Cuts. (1) Use the cylinder turned in Article 222, or a similar one, and lay it out according to Figure 280. Place

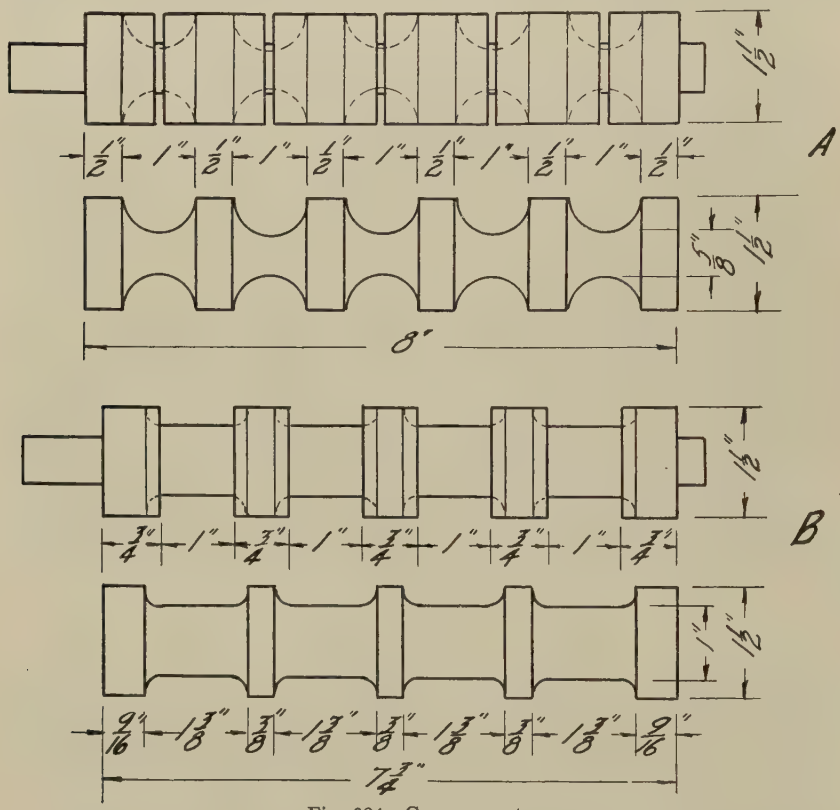


Fig. 284. Concave cuts

a rule on it, mark all the lines without moving the rule. Steady the pencil on the T rest and with its point pressed against one of the marks on the side of the cylinder, revolve the cylinder by hand so that a line is marked all around its circumference. (Fig. 281.) Repeat on all the other points.

2. Set the calipers to a little more than 1 in. in diameter, and with the parting tool, cut on the inside of the lines indicating the 1-in. divisions. (Fig. 273.) Do not cut right up to the lines, but leave a little for finishing.

3*a*. Remove the wood between the cuts with a gouge (Fig. 282), and finish with a skew chisel, making that part of the cylinder 1 in. in diameter. Hold the chisel as shown in Fig. 276.

3*b*. When using the scraping method, remove the wood between the cuts with a round-nose chisel, and finish with a square-nose or a turning chisel.

4. Finish the shoulder cuts with the skew chisel (Fig. 277), and test them for squareness with the edge of the chisel. (Fig. 279.)

Fig. 285. Making concave cuts with a round-nose chisel

5. Cut off the projections on both ends as follows: Cut down with the parting tool until the diameter has been reduced to about $\frac{3}{16}$ in. Take the cylinder out of the lathe, and saw off the projections with a backsaw. Smooth with a chisel.

Fig. 286. Making concave cuts with a gouge

224. **To Make Taper Cuts.** (1) Use a cylinder of the dimensions given in Figure 274. Lay off the measurements as explained in Article 223, and mark pencil lines at these points all around the circumference of the cylinder. (Fig. 281.)

2. Cut down to the proper diameters with the parting tool. (Fig. 273.) Allow $\frac{1}{16}$ in. more than the diameters needed on the cuts on the taper.

3. Finish the square sections on the ends with a square-nose or skew chisel.

4. With a gouge, remove the wood on the tapers almost down to the cuts by the parting tool.

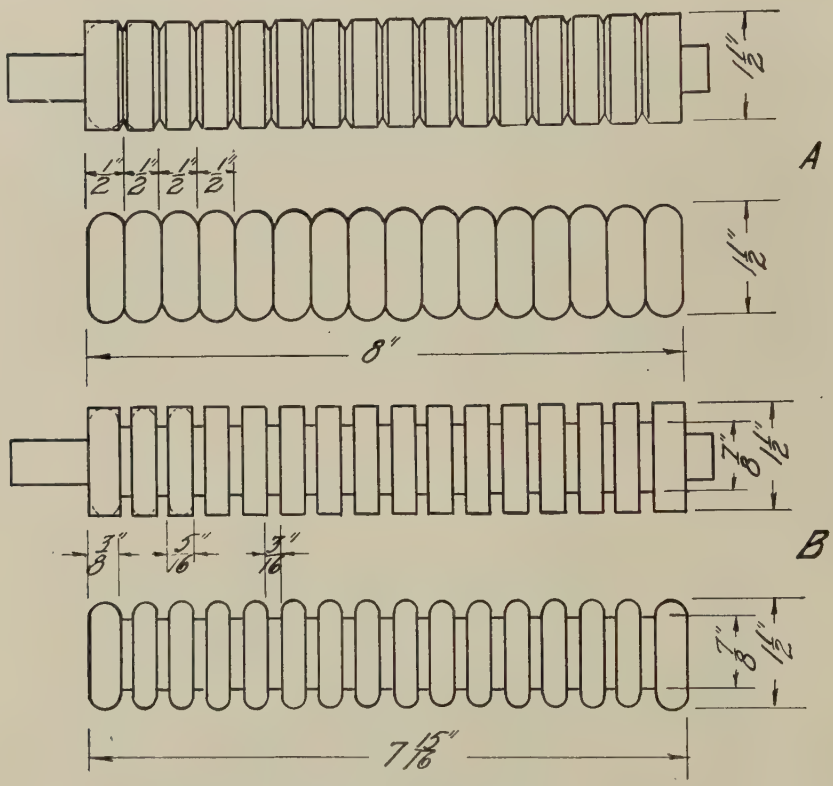


Fig. 287. Convex cuts

5. Finish the tapers with a turning chisel or a skew chisel. (Fig. 276.)

225. To Make Concave Cuts. (1) Turn a cylinder of the dimensions given in Figure 274, and lay it out as shown at A, Figure 284.

2. Set the calipers to $\frac{1}{16}$ in. more than the smallest finished diameter, and cut down with the parting tool at the centers of the curves.

3*a*. Use the round-nose chisel for making the concave cuts, holding it perfectly flat on the T rest. (Fig. 285.) Begin the cuts a little inside the lines, and gradually work down to the bottom of the cuts made with the parting tool. This is the scraping method.

3*b*. In the cutting method, concave cuts are made with a gouge. The cut is started with the gouge raised on its edge, after which it is

slowly rolled on its back until half the cut has been completed. Do the other half of the cut in the same way. (Fig. 286.)

4. Another exercise in making concave cuts is shown at B, Figure 284. Use the cylinder with the shoulder cuts (Fig. 280), and lay off the measurements as shown.

Fig. 288. Cutting beads with a skew chisel

5. Make the concave cuts with a round-nose chisel. Always hold it flat against the T rest, and be careful to make a smooth curve.

226. **To Make Convex Cuts.** (1) Turn a cylinder 1½ in. in diameter and 8 in. long as in Figure 274.

2. Lay out measurements as at A, Figure 287, and make small "V" cuts with the toe of a skew chisel.

3. Round off the sharp corners with the diamond point or skew chisel.

4. For the second exercise, proceed as follows: Lay out measurements as shown at B, Figure 287, and cut down to the smallest diameter with the parting tool.

5. In the cutting method, beads are rounded with the heel of a skew chisel. The cut is started near the center of the bead, and the chisel tipped to left and right. (Fig. 288.)

If the scraping method is used, round off the corners with the diamond point.

Beads from ⅛ to ⅝ in. in width are also made with specially shaped turning chisels called "beading tools."

6. If a turned piece has square parts, such as Figures 383 and 410, lay off these parts by squaring a pencil line on all four sides of the piece.

7. Start cutting a little outside the line with a very sharp skew chisel, resting its edge on the T rest and bringing the point gradually

in contact with the wood. (Fig. 289, A.) This will nick the corners of the square piece.

8. After a light cut with a skew chisel, cut down with the parting tool until it is in contact with the wood all around. (Fig. 289, B.)

Round off the rest of the piece with a gouge, and finish to the proper diameter as described in Article 222.

10. Finish the cut to the line (Fig. 289, C, or Fig. 277), and round the corners of the square part with a left skew chisel (Fig. 290), or a diamond point.

227. **To Sand in the Lathe on a Spindle.** Where a sanding machine is not available, spindles of different diameters may be turned, covered with sandpaper, and used very effectively in sanding concave surfaces.

1. Turn the spindle according to directions given in Article 222. It should be somewhat smaller in diameter than the diameter of the curve to be sanded, generally from ¼ to ½ in., to allow for the thickness of the sandpaper and facility in working.

2. Fold a sheet of No. 1½ sandpaper around the cylinder, and cut away the surplus so that the ends of the sandpaper just meet when it is wrapped tightly around the cylinder.

3. Apply glue to the cylinder, wrap the sandpaper around it, and hold it in place by winding a string, or better, a piece of bandage around it. Set it away to dry.

4. Place the cylinder in the lathe, applying sufficient oil to the end running on the dead center, and remove the toolrest. Curves, such as those on the legs of the footstool, Figure 380, or the stand, Figure 392, are easily sanded by holding the pieces perpendicularly to the face of the cylinder, Figure 291, and moving them rapidly back and forth. If held too long in one place, ridges and hollows will result.

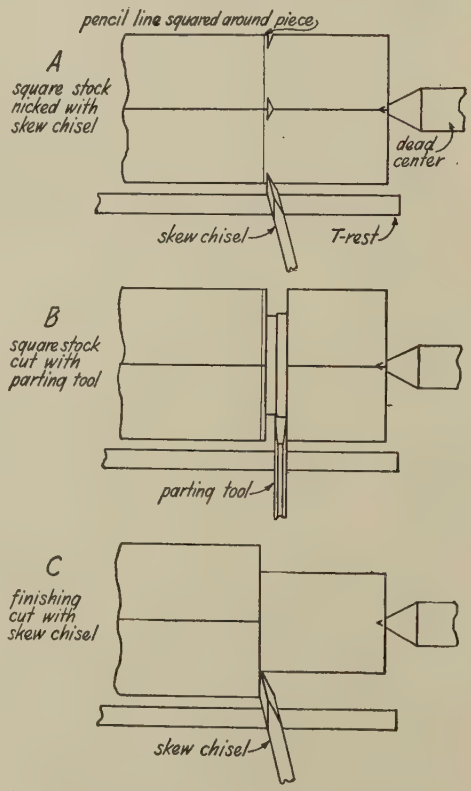


Fig. 289. Cutting a shoulder on turnings with square parts, with the point of a skew chisel

5. When it is desired to sand a curve on the end wood of a leg to be doweled to a turned column, the leg to be sanded is steadied on the toolrest. Figure 292, page 158, illustrates the method quite clearly.

228. **To Turn a Disk.** (1) A wheel or circular disk of soft wood, such as is used for sanding, is planed flat and true on one side. It is then cut as nearly round on a band saw or with a turning saw, as is possible.

2. Screw a faceplate securely to the planed side of the disk, being careful to center it as well as possible.

The screws should be rather heavy, but not too long, so that there is no danger of running the tool into them. (See Article 198, pp. 130-131, for complete directions on how to apply flathead screws.)

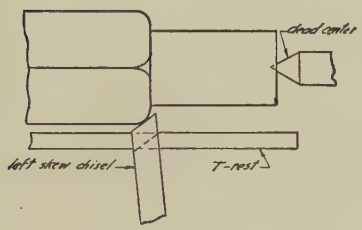


Fig. 290.
Rounding corners
with left skew chisel

3. Remove the live center from the headstock of the lathe, and screw the faceplate onto the end of the live spindle.

4. Adjust the T rest so that it is parallel to the face of the disk at right angles to the lathe bed, and only about ¼ in. away from the disk. The T rest should be placed at a height a little below the center of the stock.

5. See that the disk revolves freely, and start the lathe at its slowest speed.

6. Remove enough of the material from the edge to make the disk circular. This will diminish the vibration caused by uneven centering. This cutting is done with the toe of a skew chisel. (Fig. 293.) It is held at right angles to the face of the disk. The cut should be stopped about ⅛ in. from the rear face of the disk, as the wood is liable to split if the cut is extended all the way across the edge of the disk.

7. If the face of the disk is rough, or much material has to be removed, first use a round-nose chisel holding it flat upon the T rest and at right angles to the disk. Move the chisel across the face of the disk from the edge nearest the operator to the center and back again.

8. Smooth the face of the disk with a square-nose chisel (Fig. 294), and test for flatness with a try-square. (Fig. 295.)

9. Mark the diameter of the disk by setting a pair of dividers to a distance equal to the radius. Place one leg on the center, and scribe the circle with the other while the stock is revolving.

Another way is to set the dividers to the required diameter. Rest

one leg of the dividers on the T rest, and place it in contact with the stock while it is revolving. Bring the other leg of the dividers gradually in contact with the stock. (Fig. 296.) If two circles are marked, shift the dividers so that the points come in contact with the stock

Fig. 291. Sanding leg on spindle

Fig. 292. Sanding end of leg to fit against turned column

halfway between the two circles. When only one circle is marked, the dividers are held centrally. This method is more exact, and especially useful for smaller diameters and when the center is cut away. It is very quickly mastered.

10. Reduce the disk to the required diameter as explained in step 6.

11. Adjust the T rest parallel to the lathe bed and to the edge of the disk, and with the square-nose chisel remove the thin piece of material left on the rear edge of the disk.

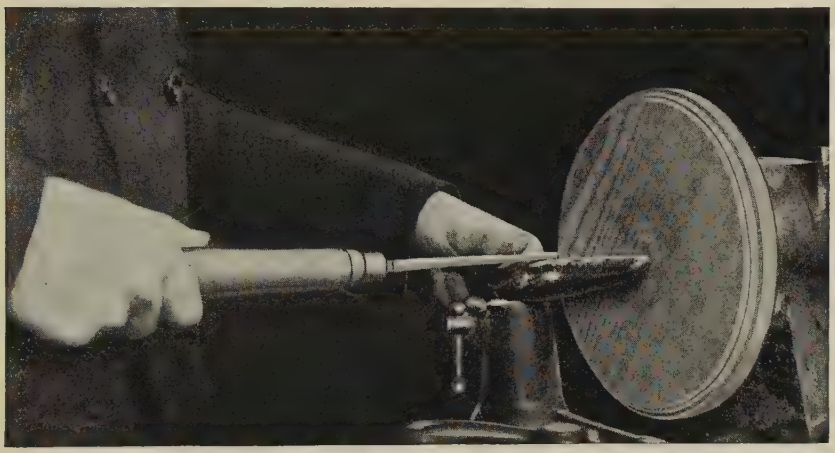


Fig. 293. Cutting edge of disk with skew chisel

Fig. 294. Smoothing face of disk with square-nose chisel

12. Test for squareness by holding the stock of a try-square against the face of the disk and the blade over its edge.

Convex and concave shapes are worked out very easily with the

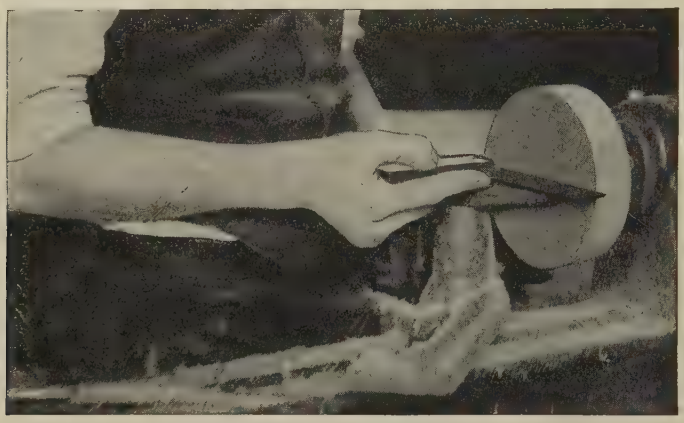


Fig. 295. Testing face of disk for flatness with try-square

Fig. 296. Marking diameter with dividers

round-nose chisel, held and manipulated as described in Articles 225 and 226.

A hole to fit a turned tenon may very easily be cut with the toe of a skew chisel held perpendicular to the face of the disk. (Fig. 297.) The center of the hole may be cut away either with the skew chisel or round-nose chisel.

229. **To Sand in the Lathe on a Disk.** A wheel or disk sander is useful for all convex surfaces. It is not recommended to sand flat surfaces on this "homemade" sander as the sides of the wheel very easily dig into the surface. It may be useful in sanding the ends of the legs of a table or stool, which does not stand evenly on all four legs.

1. From a 2-in. plank, preferably softwood, cut out a circular disk, or wheel, of as large a diameter as the lathe will swing. Cut it as nearly round as possible with a handsaw or turning saw.

Fig. 297. Cutting hole with skew chisel

2. Screw a faceplate securely to the disk, and as nearly in the center as possible.

3. Turn the disk as explained in Article 228.

4. Apply glue to the disk, and glue the sandpaper in place. If the disk is larger in diameter than a sheet of sandpaper, place two pieces edge to edge.

5. Clamp the disk to a flat surface until the glue is dry. Trim the edges with a dull chisel or plane iron.

6. When the sanding wheel is to be used, the tool post should be removed from the lathe bed and a board clamped to it instead. This

board should be thicker than the distance between the lathe bed and the edge of the wheel. (Fig. 298.)

230. To Do Chuck Turning. A chuck is an appliance in which work may be held securely while it is being turned in a lathe. Chucks are made in several different types and of different materials, as steel,

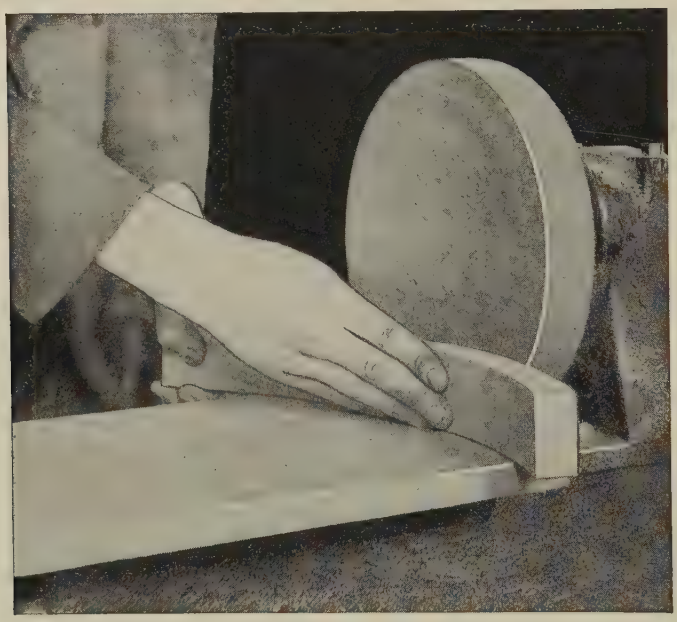


Fig. 298. Sanding convex surface on a disk

brass, or wood. The type to be described in the following consists of a turned disk of wood fastened to a faceplate or a screw chuck. The wood turner makes these chucks easily and quickly as he needs them for the work he is doing. They are used for holding such turned objects as lamp bases, trays, bowls, boxes, rings, etc.

A lamp base, such as is needed for the lamps illustrated in Figures 397 and 398, is made as follows:

1. Get out the stock for the base, plane one side, cut it round, and screw it to the faceplate as explained in Article 228, steps 1 to 3.

2. Reduce it to the thickness and diameter required. Then cut a shallow recess in its face about $\frac{1}{16}$ in. deep and extending within an inch of its outer edge. This is the lower surface of the base, and the depression is cut to make it stand well.

3. Bore a $\frac{3}{8}$-in. hole from the side of the base to its center, as shown at A, Figure 299. This hole is for the electric wires. Sand the edge and lower surface of the base, and remove it from the faceplate.

4. Turn a disk from a piece of softwood at least 1 in. larger in diameter than the base, and not less than 1½ in. in thickness. This is to be the "chuck."

5. Caliper the diameter of the lamp base carefully, and mark a circle of this diameter on the disk with a pair of dividers. (Fig. 296.)

6. Cut a recess in the disk within the circle marked. This recess should be about 3/16 in. deep. The lamp base should fit into it very

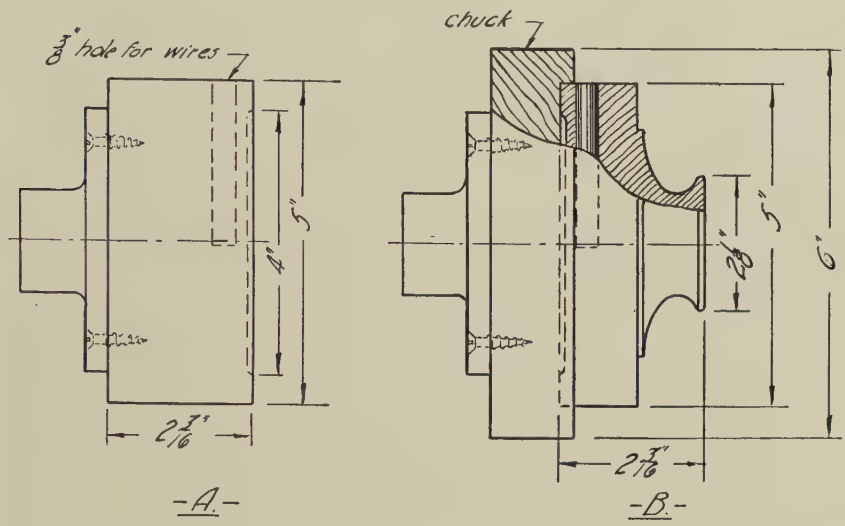


Fig. 299. Lamp base. A, base turned to size; recess cut and hole bored; B, base chucked and turned; hole for tenon of upright remains to be bored

tightly as shown at B, Figure 299. If the recess is a little too large, place a piece of paper over it, and force the base into it. If the thickness of the paper is not sufficient to hold the base firmly in the recess, face the disk off again and cut another recess.

7. Drive the base into the recess, so that its lower surface bears against the bottom of the recess. This operation is called "chucking." It is the only way in which the base can be accurately centered and turned from the opposite side.

8. If the base is chucked correctly, it will run true without any danger of coming loose. The turning may now be finished according to the drawing, after which the hole is bored to fit the tenon for the upright. (Fig. 297.)

In this case, the chuck was made by cutting a recess into it. In other cases, chucks are made by turning a shoulder on the disk, on which the object to be turned is held or chucked.

231. To Do Split Turning. Split turnings or semicircular turned pieces are used to decorate flat surfaces, such as the legs or panels of a cabinet. This method of decoration, which originated during the Jacobean period (1603-88), is used extensively on much modern furniture, often in combination with moldings. (Figs. 300 and 408.)

1. Split work is turned between centers like any other piece of spindle turning. The stock is prepared and held together in the following way:

2. Cut 2 pieces of lumber about 4 in. longer than the finished dimensions of the split turning called for. Their width should be about ¼ in. more than the greatest width shown in the drawing, and their thickness should be equal to a little more than half their width.

3. Plane the faces of these two pieces, so that they will make a perfect joint when placed together.

4. These pieces are now fastened securely together at both ends, thus forming a square in cross section. This may be done in several ways. One of the safest of these is to screw the pieces together with ordinary flathead screws set a little below the surface. (Fig. 300.) For extra security, a spot of glue may be placed between the pieces at the point where the screws enter.

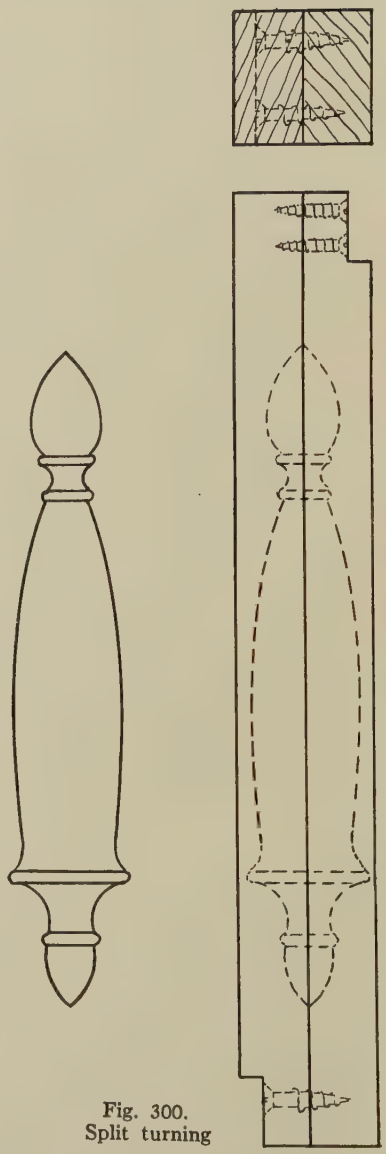


Fig. 300. Split turning

5. The stock is now fastened in the lathe, and turned as if it were a solid piece. It follows that the design is laid out in the center of the piece since there are 2 in. to spare on each end.

6. Cut the two ends away with a backsaw, and not with the parting tool. Sand the ends of the turned pieces smooth by hand.

When a turned quarter section is desired, four pieces of equal width and thickness are screwed together, and turned as explained above.

REVIEW QUESTIONS

1. What may be said in defense of the "scraping" method of turning?
2. What are the main parts of a lathe?
3. What is understood by a cone pulley? What is its function on a lathe?
4. The live spindle on a lathe is 4½ in. above the lathe bed. What is the "swing" of this lathe?
5. A shaft with a 4-in. pulley should be driven at a speed of 2400 r.p.m. If the countershaft makes 600 r.p.m., what must the diameter of its driving pulley be?
6. Why should the live center not be driven into the wood with a hammer?
7. Why should the wood not be driven onto the live center?
8. How many clamps are there to tighten on the lathe before the power can be applied?
9. What other precautions must be taken before turning on the power?
10. Why is the end of the wood running on the dead center oiled?
11. Why is the rounding of square stock started near one end rather than in the center?
12. How is a cylinder turned to exactly the same finished diameter throughout its length?
13. How may the squareness of a shoulder cut be easily and quickly tested?
14. How may the straightness of a plain or tapered cylinder be tested?
15. How is a sanding cylinder made? How is it used on a lathe?
16. Why should a disk be cut as nearly circular as possible before it is turned?
17. How is a given diameter marked on a revolving disk with a pair of dividers?
18. How is the flatness of a disk tested?
19. Why should a disk be planed flat on the side to which the faceplate is screwed?
20. Why should the screws used on faceplates and screw chucks be thick?
21. How may a curved rail or drawer front be sanded on a disk in a lathe?
22. How may a disk or plate be turned without showing screw holes?
23. What is split turning? How is it used?
24. How may the stock for split turning be fastened securely together?
25. Why should split turnings not be cut through with a parting tool?

CHAPTER XIV

SURFACE DECORATION

The most common ways of enriching or decorating a wood surface are by inlaying, veneering, carving, and painting.

While the majority of these processes require the highest type of skill and artistic ability, it is nevertheless possible to select some which, while comparatively simple to execute, are of sufficient artistic merit to greatly enhance the beauty as well as the intrinsic value of pieces of furniture such as those described in Chapter XVIII.

Great care must be taken in decorating an object. This rule is of especial importance to beginners, who, in their eagerness and enthusiasm over the new work, often overdecorate the object, or select a design or type of decoration that is unsuitable for the work in hand.

It may be said in general that surface decoration should be simple and appropriate, and should be used sparingly. The beginner should not rely entirely on his own taste, but should be guided by a study of good designs. These are easily found in museums, exhibits, books, and art magazines. In them, numerous examples of both classic and modern decoration may be studied and the proper selection made.

233. General Suggestions for Decoration. (1) Furniture, such as tables, chairs, or cabinets for the kitchen, made of soft or inexpensive woods, should not be decorated by inlaying or carving. It would be more appropriate to paint these pieces. A border or edge painted in a darker or contrasting, harmonious color would be a suitable form of decoration. If more color is desired, a decalcomania transfer may be added.

2. Inlaying, veneering, carving, or reeding are best employed to decorate or enhance the beauty of pieces on which a good deal of labor has been expended, such as small decorative tables, cabinets, lamps, etc.

Inlaying should be done only on close-grained woods, such as maple, birch, walnut, mahogany, etc. A thin line of $\frac{1}{16}$-in. satinwood is often appropriate as a border line on the front of a drawer, or on straight, tapered legs. Inlaid border lines are also used along the edges of table tops of different shapes, on cabinet doors, mirror frames, serving trays,

and similar pieces. Sometimes the corners of an inlaid top or door are made more prominent by the design of the border line itself or by inlaying special corner insets. (Fig. 387.) Occasionally an inset is placed in the center of a top, door, or tray having an inlaid border line. (Fig. 388.)

The contrast in color between the inlay and the surface should not be too glaring, but it should be sufficiently well defined to make the inlay stand out clearly.

3. The purpose of veneering is to enhance the beauty of the wood surface. A fine line of inlay is often combined with the veneers to form or accentuate a border. Insets are rarely used with matched veneers, because such veneers are decorative enough.

4. In general, it is better not to use carving and inlaying on the same piece of furniture. Carving may be done on both close- and open-grain woods. Simple forms of carving, such as are illustrated in Figures 317 and 318, are sufficient.

5. Spiral reeding and straight reeding should not be used together on the same turned column, except when the turned parts thus decorated differ greatly in length and shape. For example, straight reeds may be carved on a long tapering part of a column, while spiral reeds may be carved on a short ball-shaped part of the same column. (Fig. 391.)

6. Overlays, veined, and pierced work should generally follow the outline of the surface to be decorated. The minor parts of the design of this type of decoration, however, may differ greatly from the contour of the surface to which it is applied. The colors of two-toned work should not be strongly contrasting, but should rather be a light tone and a dark tone of the same color.

7. When using moldings, it is better to err in making them too small, rather than too large. Moldings should be smaller when made of fine-grain woods, such as mahogany or maple, and larger when made of coarse-grain woods, such as oak and ash.

INLAYING

Inlaying is often regarded by the amateur craftsman as a difficult process, quite beyond his powers, and only within the capability of the expert or specialist. This attitude of mind is always due to the fact that the person in question has never seen how inlaying is done and, therefore does not realize how comparatively simple and easy the process really is.

In general, inlaying may be explained as the process of cutting a shallow recess in one member into which another member of a different color or material is fitted and glued.

Material for inlay is made commercially in two forms: (1) lines or bands of varying widths, and (2) insets in numerous sizes, shapes, and

designs. (Fig. 301.) Lines are generally used along the edges of a surface, as a border or frame, while insets are used in the center of a surface or sometimes in corners. While it is possible to make up lines of a simple pattern, it is rather difficult to make suitable insets. From

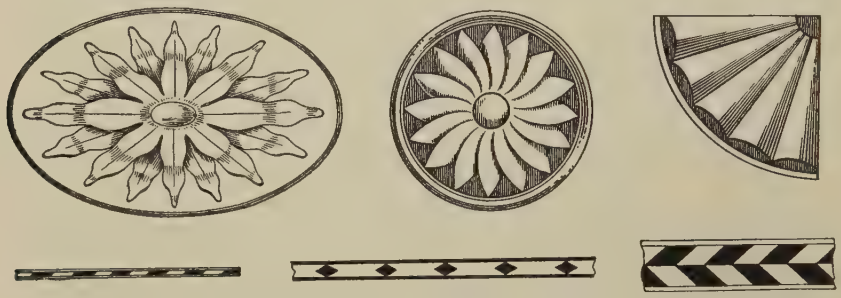


Fig. 301. Typical commercial designs of lines and insets

a commercial point of view, it does not pay, as such material can be bought very cheaply from firms making a specialty of this work. Lines are made in pieces one yard long, from $\frac{1}{28}$ to $\frac{1}{16}$ in. thick, and vary in price according to width and design. Insets are sold by the piece, and also vary greatly in price according to their size and design. They are made of many small pieces of wood of different colors, carefully cut and glued together on a piece of brown paper. The beautiful shading, so characteristic of these pieces, is executed by placing them on edge in

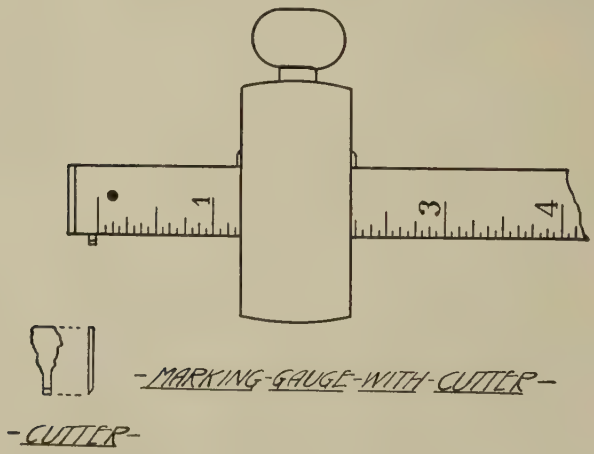


Fig. 302. Tool for cutting grooves for narrow bands of inlay

a shallow iron saucer filled with moist sand. When placed over a fire, the sand at the bottom of the saucer dries, and becomes so hot that the pieces are scorched on their lower edges.

234. To Inlay Lines or Bands. (1) Make a tool for cutting the grooves by breaking a piece off an old hack-saw blade and grinding it on an emery wheel to approximately the width of the line to be inlaid.

2. A bevel is ground on one side, after which it is sharpened just like a veneer scraper. (Art. 117.)

3. Remove the spur or point from a marking gauge, and insert the piece of steel instead, so that its sharpened edge projects about $\frac{1}{16}$ in. or less, depending upon the thickness of the band to be inlaid. (Fig. 302.)

4. Make a trial cut on a piece of waste wood to see if the groove is of the right width and depth.

Fig. 303. Cutting grooves with marking gauge

The marking gauge is held and operated in the usual manner; i.e., away from the operator. (Fig. 303.) Consequently, the beveled piece of steel is placed so that it cuts like a veneer scraper, with the flat side toward the front.

5. The inlay should fit so snugly that it must be forced gently into the groove. Therefore, if the groove is too wide, a little should be ground off the sides of the cutter until it cuts a groove of the exact width.

The above method is recommended especially for narrow lines. The cutter will cut both with and across the grain on hard, close-grain woods, as maple, birch, mahogany, walnut, etc., the smoothness of the

cut depending upon the sharpness of the cutter. The slight roughness appearing at the edges of grooves cut across the grain is removed when the inlaid surface is scraped and sanded, as directed in step 11 following.

6. For border lines up to and including ¼ in. in width, several parallel cuts may be made with a $\frac{1}{16}$-in. cutter as described herein.

7. For wider lines, it is recommended to gauge the width with a slitting gauge (Fig. 17) or a mortising gauge (Fig. 18), having the spurs filed to very sharp points. The material between the lines may then be removed with a router plane. To prevent the danger of the plane slipping outside the lines, a piece of wood may be screwed to its

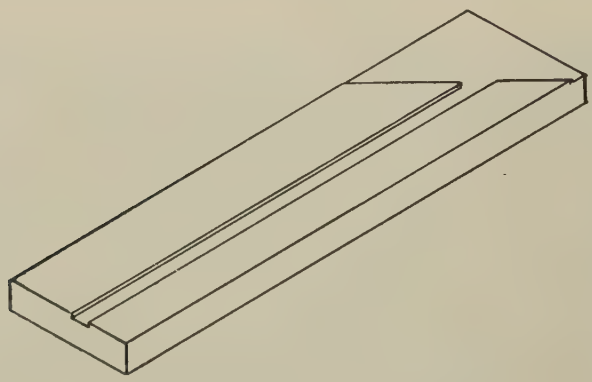


Fig. 304. Block for mitering bands of inlay

underside. This will bear against the edges of the surface to be inlaid, and act as a guide. (Fig. 310.)

8. Regulate any little unevenness in the corners with a sharp chisel, cut the lines to length, and miter them in the corners. This is best done with a very sharp chisel.

9. In a strip of wood about 2 or 3 in. wide and about a foot long, cut a groove $\frac{1}{16}$ in. deep and a little wider than the band of inlay. Near the end of the strip, lay off a line at an angle of 45 deg. Saw on this line to a depth of $\frac{1}{16}$ in., and cut a recess on the end of the wood to the same depth. This strip is used for mitering bands of inlay. (Fig. 304.)

10. When the lines have been cut to length and mitered, they are brushed with thin glue, and are forced into the grooves with a hammer, either by striking light blows on a block of wood laid over the inlay, or by running the hammer over the lines while exerting pressure on the head of the hammer. This must be done carefully so that the inlay will not be injured.

11. After drying about ten hours, the inlaid piece may be scraped with a very sharp veneer scraper until all glue has been cleaned off and

the lines are absolutely level with the surface. It is then ready for sanding and finishing.

Bands of inlay absorb some moisture from the glue which causes them to swell. As they cannot expand sidewise in the narrow grooves, they swell in an upward direction. When the water evaporates, they again shrink to their original thickness. It is, therefore, important to allow sufficient time before scraping them level with the surface. They

Fig. 305. Cutting grooves with router machine

will continue to shrink after a too early scraping, thus forming an unsightly hollow.

Grooves for line inlay can be cut very easily with a router machine. (Fig. 305.) This machine is furnished with a guide for both straight or curved work. The machine is fitted with a bit of the proper diameter and adjusted to the desired depth of cut. The guide is fastened at the correct distance and held against the edge of the piece while the groove is being cut.

235. To Inlay Insets. (1) Insets sold by manufacturers of mar-

quetry are about $\frac{1}{28}$ in. in thickness. They are glued to a piece of brown wrapping paper and are set in the center of a piece of veneer in order to protect the edges. Cut away this surplus veneer with a sharp pocketknife by slicing it into narrow strips. After all of the strips have been carefully broken away, it will be found that bits of paper project all around the edges of the inset. This surplus paper is best removed by running a fine file, as for instance a saw file, lightly over the rear edge of the inset, which is the side to which the paper is glued.

2. When the edges have been cleaned, the inset is placed face down on the surface at the place where it is to be inlaid.

3. If the inset is elliptical, for example, and it is to be inlaid in the center of a tray or table, two center lines crossing each other at right

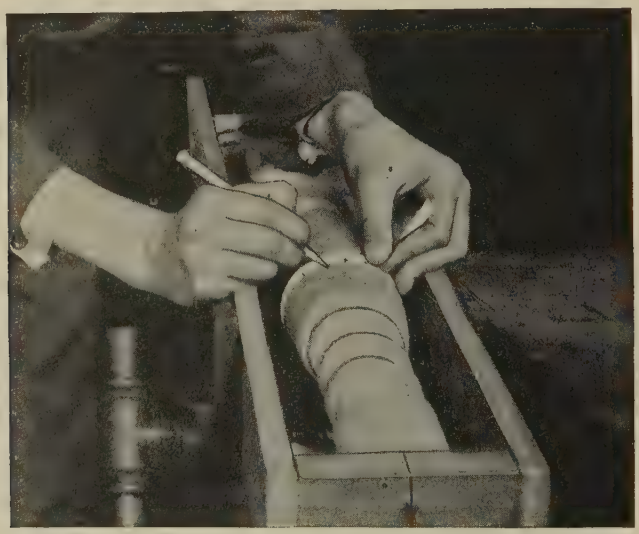


Fig. 306. Laying off reeds from paper strip

angles are laid out both on the tray and on the inset. The inset is then placed face down so that the center lines coincide and its outline is traced on the surface with a sharp hard pencil. As the inset may not be absolutely symmetrical, it is also well to mark it so that it will always be placed in the same position.

4. If the inset is diamond shaped, the straight lines forming the outline may be cut with a chisel, but if it is elliptical or circular, the outline, in the absence of special tools, can be cut with a sharp pocketknife or gouges of the proper curvature.

5. The wood within the outline is cut to a depth of about $\frac{1}{28}$ in. with a router plane. Set the plane so that it cuts only a thin shaving

until the desired depth, equal to the thickness of the inset, has been reached.

6. Fit the inset into the recess just cut. If it does not go in all the way around, mark the places to be cut with a sharp knife and remove the projections little by little until the inset fits into the recess.

7. Glue the inset in place *face down*, so that the brown paper faces up. Press it into the recess with a chisel, working the chisel from the center toward the edges, thereby forcing out the surplus glue. Keep

Fig. 307. Gauging reeds from division marks

working the glue out with the chisel for 5 to 10 minutes until the glue has set and the inset is firmly imbedded in the recess.

8. After allowing about 10 hours for drying, the inset and surrounding surface is scraped with a veneer scraper and sanded smooth. This will remove the brown paper so that the colors and shading of the different pieces of wood, of which the inset is composed, appear in all their beauty.

If an inset is glued in place with the paper side down, a good bond is not formed between it and the wood into which it is inlaid, because the paper is liable to split, causing the inset or parts of it to become loose.

236. To Cut Straight Reeds. The beauty of a turned column, such as illustrated in Figure 309, may be greatly enhanced by reeding. A reed, in this sense, may be defined as a semicircular molding or bead; in architecture, it is known under the name "astragal." A reed is really very easily carved by hand, and the time and patience needed for its execution is fully repaid by the added beauty and intrinsic value of the piece of furniture thus decorated.

1. The first step in the process of reeding is to make a box having neither top nor bottom, but only the four sides which may be nailed together. The size of this box should be such that the piece to be reeded will fit easily within its four sides. (Fig. 307.)

Fig. 308. Chiseling "V" cuts

2. The piece to be reeded is held in this box with a screw driven through each end of it into the holes left by the lathe centers.

3. Lay out vertical center lines on each end, and bore a $\frac{3}{16}$-in. hole for the screw in each of these lines, so that the part to be reeded will be nearly level with the top edges of the box.

4. Determine the number of reeds to be cut. Wrap a strip of paper around the thickest part of the column. Cut it so that the ends just meet, and divide it into the desired number of parts.

5. Wrap the paper around the column again, and lay off the divisions. (Fig. 306.)

6. Place the column so that one of these marks is approximately equidistant from both sides of the box. Set a marking gauge with the block against one of the sides and the point on the mark, and gauge a line throughout the length to be reeded. (Fig. 307.) It is best to bring the point of the marking gauge all the way out, so that it can reach the smaller diameters of the column.

Fig. 309. Beautiful example of reeding done by hand

7. Repeat at all the other marks of division, being careful to hold the block of the marking gauge against the same side of the box.

8. Wedge the column firmly against the sides of the box, and chisel a V cut on one of the gauge lines. A carver's veining tool or skew chisel, or an ordinary ½-in. paring chisel having beveled sides, may be used, for this work. (Fig. 308.) Be careful to see how the grain runs, taking small cuts and reversing the direction of the cut whenever necessary.

9. When the V cuts have been made sufficiently deep, the sharp edges are rounded, thus forming the beads or reeds.

10. These are further smoothed with scrapers and sandpaper.

Flutes may be laid out and cut in the same way, but it is more difficult to get them smooth and even.

Flutes on straight work may be cut with a router plane. (Fig. 310.) A fluting cutter, like those furnished with the universal plane, Figure 46, should be used. The plane is guided by a wooden block screwed to its underside.

Reeds and flutes are very easily cut with a router machine. The piece to be reeded is placed between the lathe centers. A board is

fixed parallel to the bed of the lathe, so that it is about 1 in. below the center of the live spindle. The router, fitted with the appropriate holder, guide, and cutter, is moved along this board, while at the same time it is being held against the piece to be reeded or fluted. A cog-wheel attachment, for the purpose of dividing the piece into a suitable number of equal parts, can also be furnished with the attachment.

237. To Cut Spiral Reeds. (1) Place the column to be reeded in

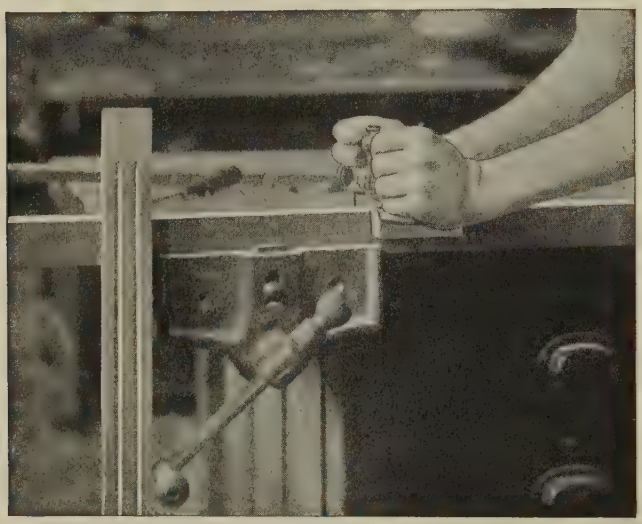


Fig. 310. Cutting flutes with router plane.
Note guide block screwed to plane

the lathe. Wrap a strip of paper around the column at each extremity of the part to be reeded, and divide the two strips into the same number of equal parts. If the diameters of the column are different, it follows that the divisions on one strip of paper will be larger than on the other.

2. Determine the pitch the reeds are to have. This is done according to the desire of the workman. The reed may go once around the column or only halfway. In either case, a straightedge is cut from a piece of cardboard or other flexible material, and is wrapped around the column so that each end of the cardboard touches one of the division points marked at each extremity of the column. (Fig. 311.)

3. Draw a pencil line along the edge of the cardboard as it winds around the column. Move the cardboard to the next pair of division points, and mark a line along its edge as previously done. Continue around the column in this way until all the reeds have been marked.

4. Chisel a V cut along these lines, as explained in Article 236,

round off the sharp corners, and smooth the reeds with scraper and sandpaper.

It will be found that the shaping of spiral reeds is easier than the straight ones, because the cutting is done at an angle to the direction in which the grain runs. There is, therefore, less chance of the chisel following the grain rather than the line marked.

238. To Carve a Single Spiral on a Turned Cylinder. (1) Turn the cylinder to the required diameter, and determine the number of turns the spiral is to make. It is customary to make the length of each turn approximately equal to the diameter of the cylinder.

2. Divide the length of the cylinder into that number of equal parts, and mark a heavy line at these points while it is revolving in the lathe.

3. Divide each of these major parts into four equal parts, and mark lighter circles at these points, Figure 312, A.

Fig. 311. Laying out spiral reeds

4. Wrap a strip of paper around the cylinder and divide it into four equal parts. Mark these divisions on the cylinder, move the T rest close to it, and draw longitudinal lines along it at these points as in *a, b, c, d,* Figure 312, A.

5. Draw the spiral line, beginning at the left end of the cylinder on one of the longitudinal lines, for example *a*. Continue toward the right to where the next line *b* intersects the first circle, and so on. When the first heavy circle is reached, the spiral should have made one complete turn around the cylinder. Proceed in like manner until the end of the cylinder has been reached. Do not let the spiral line begin or end too abruptly, but make it more parallel to the turned beads at both ends.

6. The carving is done as follows: With a backsaw, make a shallow cut on the spiral line, at the same time revolving the lathe slowly by hand. Chisel down to the bottom of the saw cut from each side, thus forming a V cut. File along the bottom of the V cut with a round file,

and work out the shape with rasp, file, scrapers, and sandpaper. These operations, which are quite easy, are shown at the left in Figure 313.

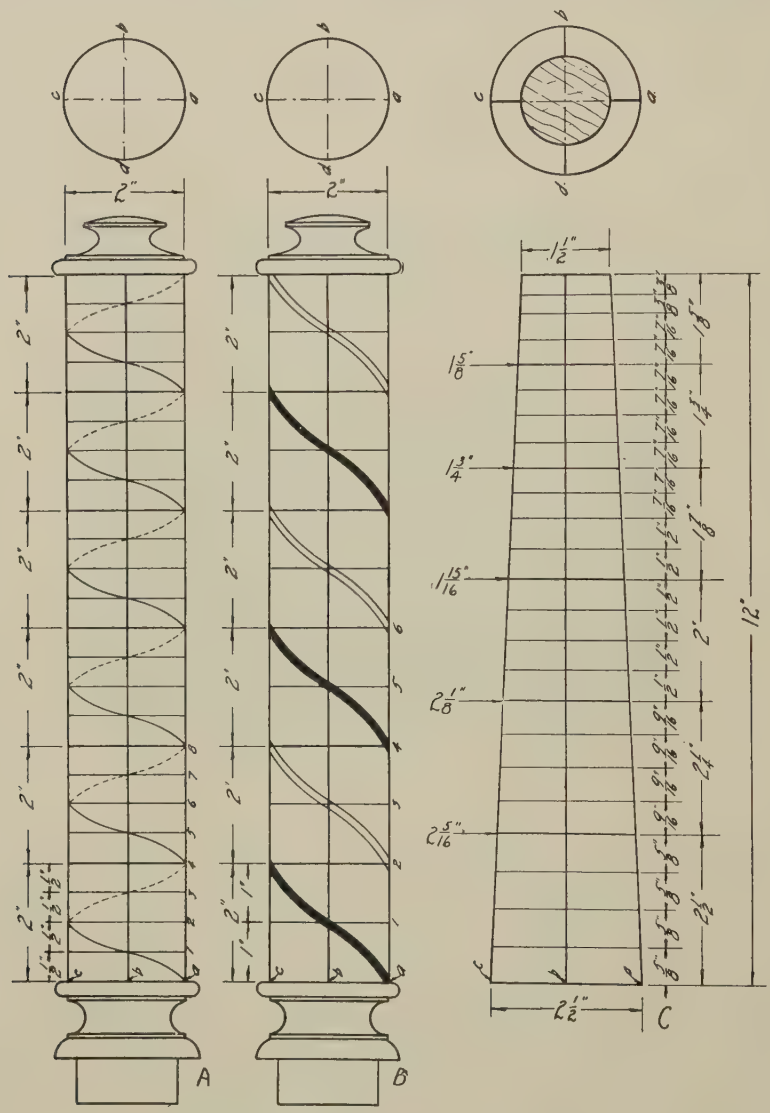


Fig. 312. Layout of single, double, and tapered spirals

239. To Carve a Double Spiral on a Turned Cylinder. (1) When a double spiral is to be carved, proceed as explained in Article 238, steps 1 to 4, but divide each of the major divisions into two equal parts only. (Fig. 312, B.)

2. Draw the first spiral, indicated by the heavy black line, from *a* to line *b* and circle 1, then to *c* and circle 2, and so on, until at line *a* and circle 4 one complete turn has been made.

3. The second spiral, shown by the fine lines, begins on the opposite side of the cylinder at line *c*, continues to line *d* and circle 1, and from

Fig. 313. Single and double spirals

there goes to line *a* and circle 2, and so on. For the sake of clearness, these spiral lines have been shown on only one side of the cylinder.

4. Figure 313 shows two double spirals. The one in the center, resembling two pieces of rope twisted together, is carved exactly as explained in Article 238, step 6.

5. The hollow double spiral at the right in Figure 313 is laid out as shown at B, in Figure 312. The spiral lines in this case form the ridge, and are $\frac{3}{16}$ in. wide. They may easily be laid out from a strip of heavy paper $\frac{3}{16}$ in. wide wrapped around the cylinder.

6. The sawing should be done on a line marked between the spiral lines starting at line *a* and circle 1, continuing to line *b* and circle 2,

and so on. This line has not been shown in the drawing as it might prove to be confusing.

7. The spirals are worked out with chisel, rasp, file, and sandpaper. Spirals should not begin or end too abruptly.

Fig. 314. Floor-lamp base showing carvings of beads and acanthus leaf

240. To Lay Out Tapered Spirals. (1) Wrap a strip of paper around the cylinder, divide it into four equal parts and draw four longitudinal lines on the cylinder. (Art. 238, step 4.)

2. Measure the diameter at the largest end of the tapered cylinder, and lay off this distance along one of the horizontal lines.

3. Then measure the diameter at this point, and lay off this distance along the cylinder. Continue in this way until the small end of the cylinder has been reached.

4. Adjust the various lengths so that they diminish proportionally, and so that the sum of their lengths equals the total length of the tapered cylinder.

5. These major divisions are again divided into two or four parts according to whether a single or a double spiral is to be carved.

Spiral turning, which is of eastern origin, was introduced in Europe

in the seventeenth century by Portuguese explorers. It is done commercially on special lathes.

SIMPLE CARVING

Wood carving, even in its simplest forms, adds much to the beauty and distinction of a piece of furniture. As this art cannot be learned very readily from written instructions only, the easiest way for the beginner is probably to try to imitate some simple border or ornament such as those illustrated in Figures 317 and 318. This, in most cases,

Fig. 315. Beaded table leg

will be found surprisingly easy, especially if an actual carving can be had for a model.

In selecting a carved ornament for a piece of cabinetwork, the student should consult books on historical ornament in order to have the carving of a form and type that is in keeping with the period of the piece of furniture which he is constructing.

TOOLS

The beginner needs only a few carving tools, such as a ½-in. skew chisel, two or three straight gouges of medium curvature, ⅛, ¼, and ⅜ in., a veining tool, and a parting or V tool. (Fig. 56.)

241. **To Cut Beads.** Beads, such as those shown on the legs of the floor lamp and the table in Figures 314 and 315, are made with a tool called a "scratch stock." This tool consists of a piece of hardwood, into which a cutter, made of an old saw blade or other piece of thin steel, is inserted. The cutter is ground to shape on an emery wheel and is beveled like a cabinet scraper. The procedure is very similar to the cutting of straight reeds explained in Article 236.

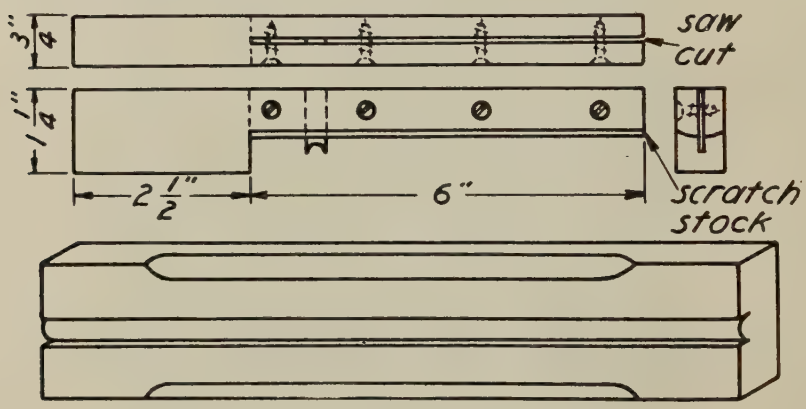


Fig. 316. Chamfers, hollows, and beads

All sorts of beads and small moldings can be made with a scratch stock, such as beaded rails and stretchers, and chamfers and hollows, as shown in Figure 316.

242. **To Cut Chamfers and Hollows.** Stopped chamfers do not extend all the way along the edge of a board, and, therefore, cannot be planed except on a portion in the center. They may be chiseled with a skew chisel. The cuts should be rather short and somewhat across the grain, so as to avoid the danger of having the chisel run into the wood below the lines. Finish with scrapers and sandpaper.

Hollows are chamfers which have been curved with a gouge. First plane the chamfer, and then chisel the hollow in the center with a gouge of the proper diameter and curvature. The sharp edges of the chamfer determine the width of the hollow. Chamfers and hollows also may be made with a scratch stock.

243. **To Carve Borders.** Other examples of carving made with the gouge only are illustrated in Figure 317 at *a*, *b*, *c*, *d*, and *e*.

1. The border at *a* is cut by first driving the gouge into the wood almost perpendicularly, and then taking a slanting cut, almost horizontally, into the first cut, so that a hollow is formed. This border is further embellished with a fine line cut on each side of it. This may be

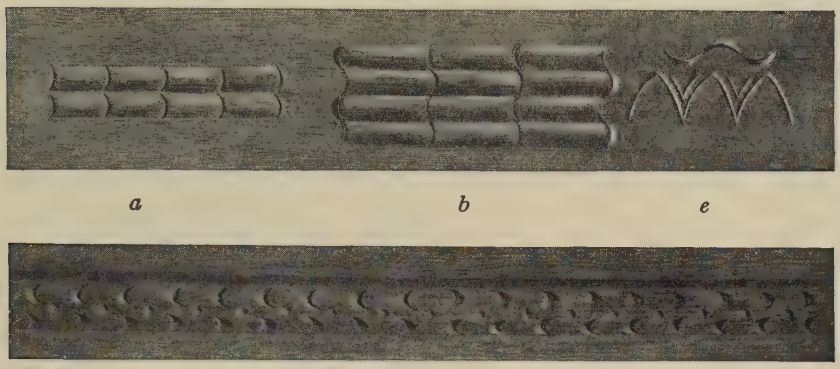


Fig. 317. Simple carved borders

cut with a V tool, or it may in some cases be scratched with a marking gauge.

2. The border *b* is a variation of *a*, the only difference being the direction of the cut. While the two bands in *a* were cut in the same direction, each two adjoining bands in *b* are cut in opposite directions.

3. Borders *c* and *d*, although quite different in appearance, are cut in the same manner as *b*; i.e., one perpendicular cut and one slant-

Fig. 318. Simple carving

ing cut running into the first. The difference is that the slanting cuts in these borders are much steeper than in *b*.

4. *The strapwork* shown at *b*, Figure 318, is a very popular and quite simple form of wood carving. In this example, the outline has

been cut with a V tool, after which the band between these outlines has been hollowed with a gouge.

It is more common in strapwork to leave the bands in relief and cut down the background to a depth of about ⅛ in. (Fig. 319.) The usual procedure is to cut the outline of the bands with a flat chisel held perpendicularly. A mallet is used to drive the chisel into the wood. Be careful not to undercut the bands because the edges are liable to crum-

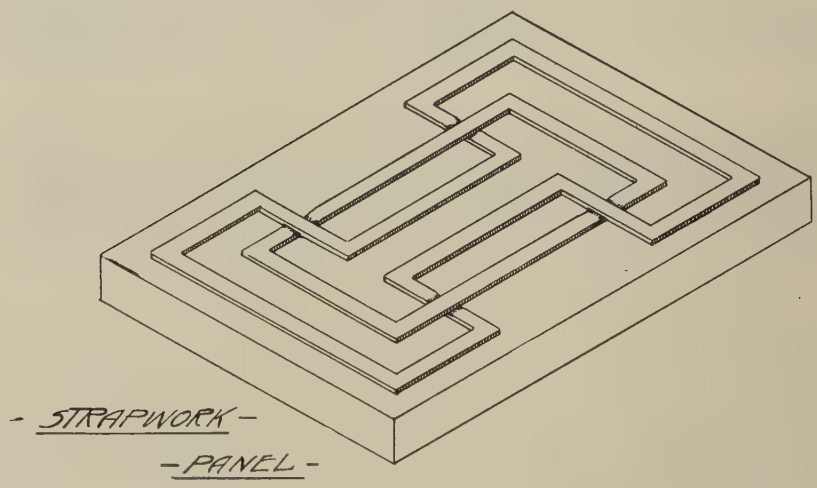


Fig. 319. Strapwork

ble and break. Then make slanting cuts meeting the perpendicular cuts, gradually working toward the center of the background.

The router machine described in Article 101 is a very useful tool for cutting away the background.

5. A very effective and easy form of carving, made by a combination of perpendicular and slanting cuts as explained above, is shown at *a*, Figure 318.

6. The border at *e*, Figure 317, shows outline carving done with a V tool. While this appears the most simple and easiest of the types described, it takes quite a good deal of practice to be able to cut these fine lines so that they are of a uniform width and closely follow the curves or straight lines of the design.

7. Carvings, such as the acanthus leaves illustrated in Figures 314 and 320, are not difficult to make for the beginner, especially if he has a model from which to work. It is recommended first to outline the rib running through the center of the leaf, then shape the latter roughly, and finally cut and shape the small individual leaves.

MOLDINGS

The appropriate use of moldings adds much to the beauty and character both of cabinetwork and interior woodwork. Like carving, it is the play of light and shadow over the uneven surface which attracts the eye to a molding. Moldings are therefore used to accentuate certain parts of a piece of furniture such as a cornice, a base, or a panel. (Fig. 321.)

Fig. 320. Acanthus leaf

Moldings are either plain or carved. They are made in a great variety of shapes, and are known by many names of Greek, French, Latin, and English origin. Some of the most common moldings are: the band, the sunk or raised fillet, the round shapes such as quarter, half round, and three-quarter round, the bead or astragal, the hollow shapes or cove moldings made in several degrees of curvature, and the combination round and hollow moldings called "cyma" and "ogee" moldings. (Fig. 322.)

244. To Make Moldings. Moldings are usually cut on the shaper or planed by hand with special molding planes or with a universal plane.

They also can be worked out roughly on a circular saw and smoothed with chisels, gouges, or scrapers. The method of procedure in the latter case is as follows:

1. Square the stock from which the molding is to be made, and lay out its profile on one end of the stock.

2. Make a number of saw cuts on the circular saw in the manner suggested in Figure 323. All square and flat surfaces of the molding can be cut exactly in this way. All curved surfaces can be cut only approximately to shape.

3. The curved surfaces are now smoothed with sharp chisels and

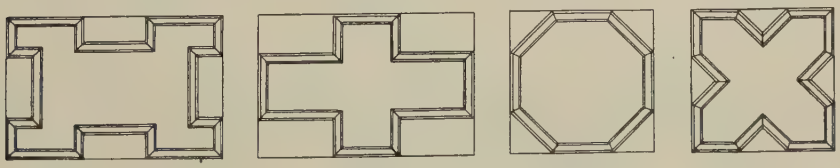


Fig. 321. Panels decorated with moldings

gouges, after which they are scraped with molding scrapers, whose edges are filed to conform to the shape of the molding.

4. The final smoothing is done with sandpaper folded over small

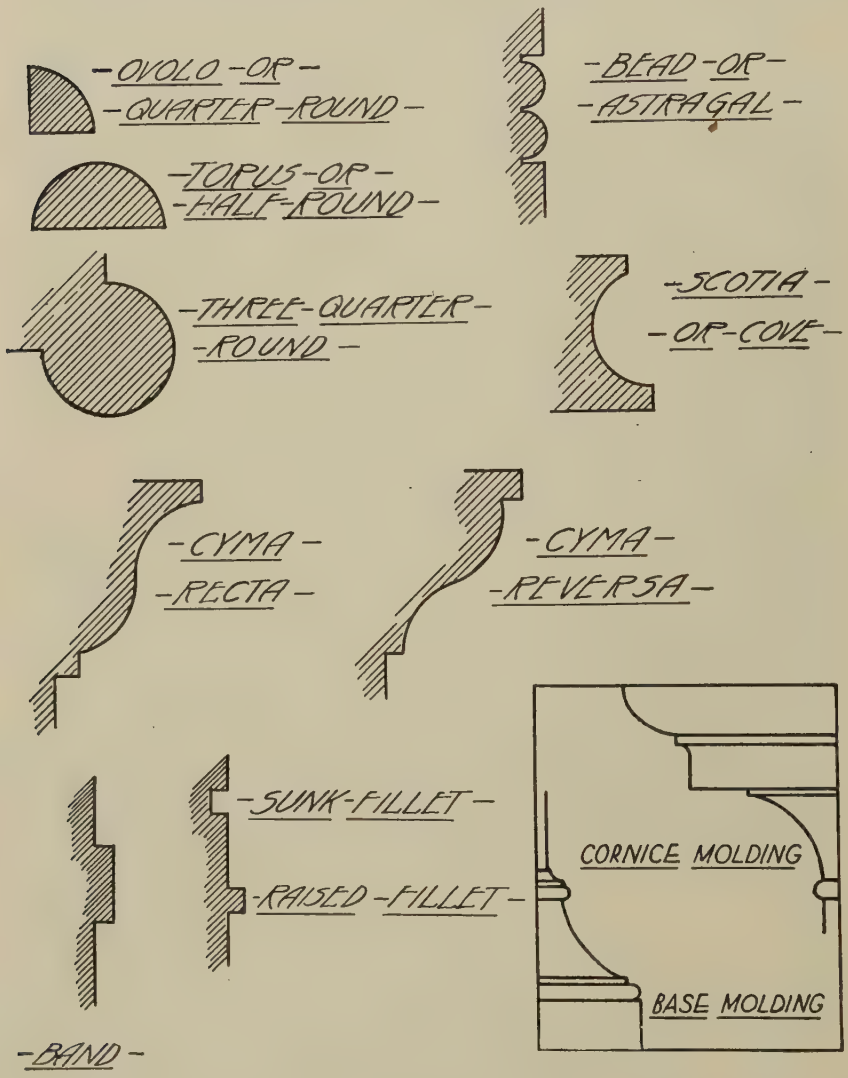


Fig. 322. Types of moldings

pieces of wood, which are shaped to fit different sections of the molding. These pieces of wood, called "rubbers," should be at least 4 in. long.

245. **To Miter and Apply Moldings.** (1) A molding is mitered

correctly around any angle by halving or bisecting the angle and cutting the ends of the molding accordingly.

2. Moldings may be mitered on a circular saw, on a wood trimmer, or in a miter box. It is extremely important that corresponding pieces are exactly of the same length.

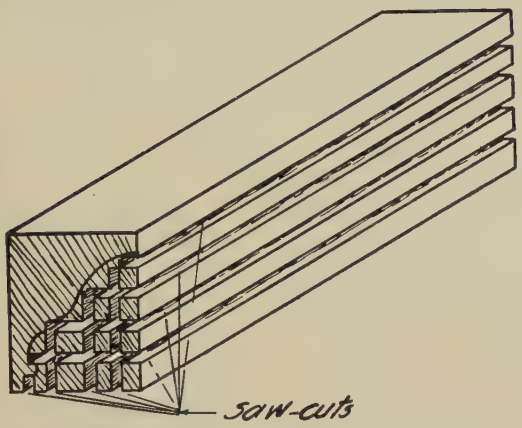


Fig. 323. Molding cut approximately on the circular saw

3. Where it is possible, decorative moldings should be glued and held in place with clamps, wedges, or hand screws until the glue is dry. (Art 195.) When this is impracticable, the moldings are glued and held in place by fine brads. When the glue is dry, these brads may either be withdrawn or set below the surface with a fine-pointed nail set. The holes in the molding made by the brads may be plugged with crack filler.

246. To Cope Moldings. (1) Mitered joints often open up in the inside part of the joint (Fig. 324) because the wood shrinks across the grain, but not along the grain. (Art. 301.)

2. To overcome this defect, moldings are sometimes coped, that is, a section is cut out of the end of one member so that it fits exactly over

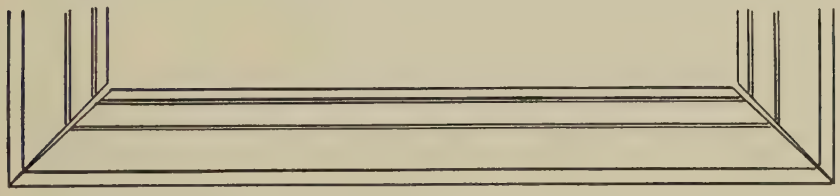


Fig. 324. Open miter joints due to shrinkage

the curves and flat surfaces of the other member. (Fig. 325.) This is done as follows:

3. If the moldings to be fitted form an angle of 90 deg. with each other, square the end of one of the members, and miter the other in the usual way at an angle of 45 deg. (Fig. 325, A.) The mitered part of this member is now cut away with a coping saw. The saw is held so that its blade is at right angles, or slightly less than a right angle, with the back of the molding. The line of the miter cut on the face of the mold-

ing must be followed closely in sawing the coping. (Fig. 325, B.) If the cut is made carefully, the coped member will now fit accurately over the squared member, and the joint will look exactly like a mitered joint. The same method is followed in coping moldings at other angles.

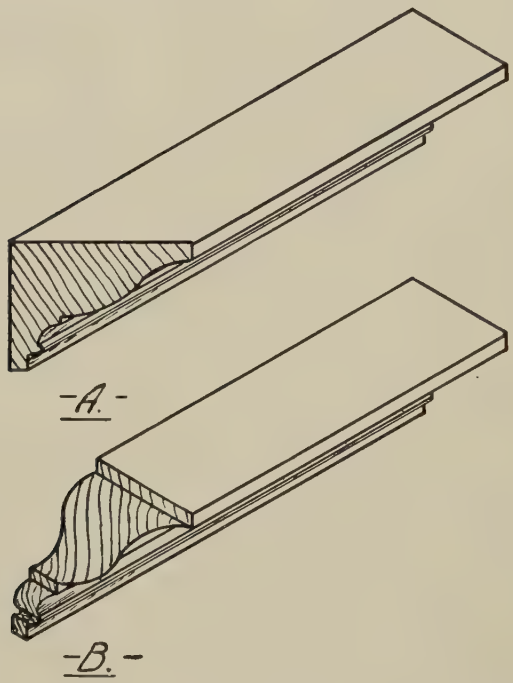


Fig. 325. A, Molding mitered at 45 deg. B, The same molding coped

247. To Shape the Edges of Table Tops. In order to make a table or cabinet more attractive and interesting, the edges of the top may be shaped or molded in different ways.

1. The edges shown in A, B, and C, Figure 326, are all produced in

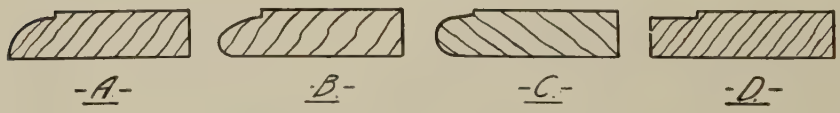


Fig. 326. Shaped edges of table tops

the following manner: Cut a shallow rabbet, about $\frac{1}{16}$ in. deep and from $\frac{3}{4}$ to 1 in. wide, on the face of the top as shown in D, Figure 326. If a circular saw is available, this may be very easily done by making

two cuts at right angles to each other. The rabbet may otherwise be planed with a rabbet plane. (Art. 146.)

2. The edge is now planed to the desired shape with a small plane, such as a smooth plane, a block plane, or a bullnose plane. Make a cardboard or thin wood template of the desired shape, and test the edge frequently while it is being planed.

3. Scrape and sandpaper the edge until it is smooth.

4. The edges shown at A and B, Figure 327, are simply rounded with a jack plane according to lines marked with a pencil, or with a marking gauge. (Fig. 327, C.) If the table is round, a circular plane or a spokeshave is used instead of a jack plane. These edges are smoothed with a cabinet scraper and sandpaper.

5. The beaded edge, D, Figure 327, is formed by scratching two lines with a marking gauge. The sharp corners thus formed are rounded with scraper and sandpaper. (See Reeding, Art. 236.)

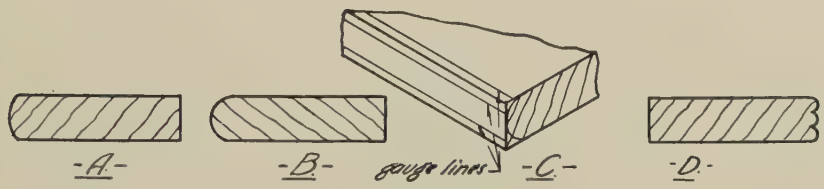


Fig. 327. Rounded and beaded edges of table tops

248. **To Match and Apply Veneers.** Veneers for decorative purposes are usually cut and arranged, or matched, in such a way as to form beautiful patterns. Rare woods that would twist and split in the solid may be used in veneering; this method of decoration, therefore, greatly enhances the beauty of a flat surface. Lines of inlay are often combined with veneers. For the best results, veneering should be done on both sides of a board. (See manufacture of Plywood, Art. 309, page 243.)

1. Lay out the pattern, in which the veneers are to be combined, on the surface to be veneered.

2. For a simple pattern like that illustrated at A, Figure 328, select a piece of plain, straight-grain veneer.

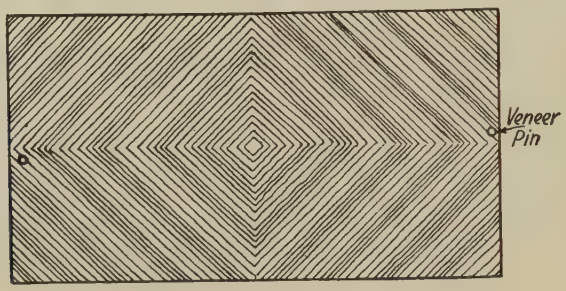
3. Cut it at an angle of about 45 deg., using a straightedge and a veneer saw.

If a veneer saw is not available, teeth may be filed on the edge of a knife as shown in Figure 329.

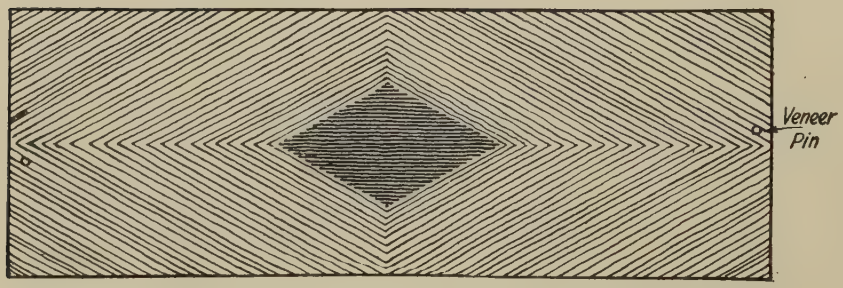
4. Place the cut edge of the veneer along one of the center lines previously marked on the board, and fasten it with a couple of veneer pins, or fine nails. These should be driven only part way, so that they can be easily extracted.

5. Place the straightedge over the other center line, and cut as before.

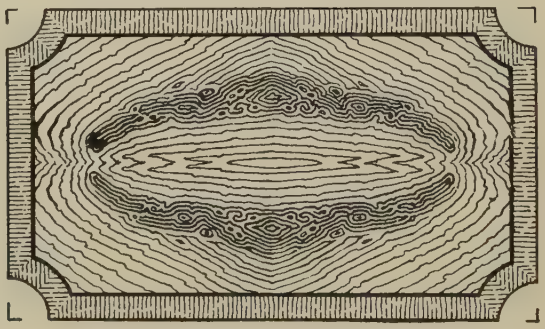
6. Reverse the sheet of veneer, and place it against the edge just cut. See that the two edges make a perfect joint, fasten it with veneer



A



B



C

Fig. 328. Matched veneers

pins, and cut along the other center line. Repeat this process until the four pieces have been cut and tacked in place.

7. Glue veneer tape or narrow strips of wrapping paper over the four joints.

8. Remove the veneer pins, except two, one on each side of a center line. Mark a circle around these with a pencil, so that they can be easily located and the veneer placed in exactly the same position.

9. The pattern B is a variation of pattern A. In this pattern the angles are not 45 deg., but the method of cutting them is exactly the same. The four outside pieces are cut and taped to the inside one so that the grain runs as shown. This pattern may be finished with a border all around.

10. Pattern C is built up of four identical pieces of veneer cut from the same log. After cutting and tacking them in place, the concave corners are cut with the sharpened point of a pair of dividers.

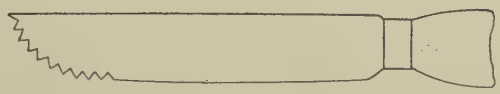


Fig. 329. Teeth filed on edge of knife for cutting veneer

11. A line of inlay is then cut and fitted around the edges, after which the outside narrow strips are cut across the grain, fitted, and taped in place.

249. To Glue the Veneers. (1) Heat the glue and a sheet of zinc large enough to cover the surface. Also adjust the veneer press, or clamps for smaller pieces, and prepare a "caul."

A caul is a piece of wood which is placed over a surface for the purpose of distributing the pressure. For curved surfaces, a caul must be shaped so that it fits the surface exactly.

2. Apply the glue only to the surface to be veneered, and *never to the veneer.* The veneer would absorb the moisture from the glue, which would cause it to swell at the time of gluing. At the subsequent drying it would contract and open up.

3. Place the veneer carefully in position, and drive the two flathead pins, one on each side of the center line, all the way home.

4. There is no need for hurrying, as the glue should be gelatinous before the hot zinc plate is applied. Put the work in the veneer press, face up. Place the hot zinc plate directly on top of the veneer, and then the caul on top of the zinc plates.

5. Apply the pressure quickly, starting in the center, so that the melting glue has an opportunity to ooze out.

A plain veneer may be glued to the opposite surface at the same time. In this case, two cauls, and two zinc plates are used. The zinc plates may be omitted if the cauls are heated on a steam table.

6. Leave the work 24 hours in the press. If, on removal, it should be found to have a blister, this may be repaired as follows:

7. Slit the blister with a sharp knife, heat a flatiron and some glue.

Force a little glue into the slit, wet the spot with water, and apply the hot flatiron.

8. Trim and smooth the edges of the veneer. Remove the two veneer pins by inserting the edge of a chisel below the heads.

9. Smooth the veneer with a scraper and sandpaper.

As an aid in predetermining the pattern the veneers will form when cut and combined at different angles, an angle mirror (Fig. 330) should be used. An angle mirror may be easily made by fastening two mirrors about 5 in. wide and 20 in. long to two pieces of wood, which are hinged together on the 5 in. edges. Placing such a mirror over a piece of veneer, and opening it to an angle of 90 deg., will show the various pat-

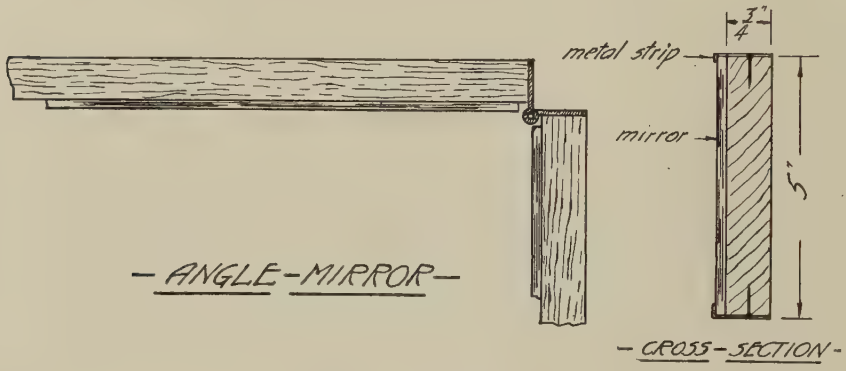


Fig. 330. Angle mirror

terns possible where four pieces of veneer are combined. An angle of 45 deg. will show the pattern when eight pieces are to be cut, and so on.

250. To Decorate by Overlays, Frets, or Veining. The chief object of these types of decoration is to relieve the monotony of a surface by a suitable design applied to it or outlined on it in two different shades of a color.

1. Overlays, as the name implies, are pieces of thin wood applied on top of a surface so as to form a raised part. (Fig. 332.) They should be made of selected grades of veneer with beautifully figured grain, and may be built up with plywood to various thicknesses. They are generally stained a lighter tone than the surface they decorate.

2. Frets are pierced overlays used especially as a decoration on panels. They are often stained darker than the panel to which they are glued. Both panel and fret should be finished before gluing. Glue should be applied very sparingly to the back of the fret, so that it will not be squeezed out on the panel.

Grilles are frets or latticework set in an open frame, such as on a phonograph or in doors of bookcases. They are sawed out of plywood.

3. Veining consists of a thin line of pleasing patterns, carved with a

veining tool or a machine router, to decorate a plain surface. (Fig. 331.) As a method of decoration, it is almost identical with overlays.

In some cases, the part within the line is stained a different shade from the part without the line, called "two toning," and in others the line itself is colored to make it stand out more clearly.

4. In the latter case, stain and fill the wood as described in Chapter XVI, and clean the filler out of the line with a pointed stick.

5. Apply a sealing coat of shellac or lacquer, and sand smooth.

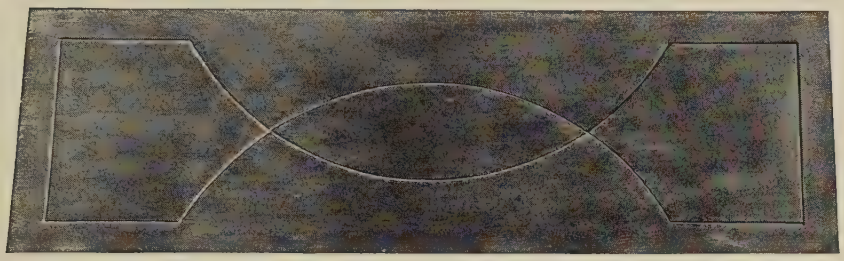


Fig. 331. Veined panel

6. Apply the vein line color over the sealing coat with a fine-pointed artist's brush.

251. To Apply Decalcomania Transfers. Decalcomania transfers are very good and pleasing substitutes for inlays, overlays, and hand-painted decorations. (Fig. 332.) The designs for these transfers, which are uniformly excellent, are first painted by the artist on copper plates or lithographers' stones, after which they are printed on a special gummed paper. By a patented process, a leading manufacturer has succeeded in reproducing the artist's brush marks in actual relief, so that they may be felt by running the hand over them as in the actual painting.

Decalcomania transfers are manufactured in a great variety of designs, as classical, modern, Chinese motifs, and juvenile motifs. They are, therefore, suitable for decorating any conceivable kind of furniture, and may be applied both on transparent or opaque finishes.

1. Smooth and clean the surface to which the transfer is to be applied, and use it only on lacquer or varnish finishes. On transparent finishes, it should be applied before the last coat; on opaque finishes after the last opaque coat.

2. Paint the color side of the transfer with a *very thin* coat of special cement prepared by the manufacturer, or a quick-drying varnish, and allow it to dry until it becomes very sticky or "tacky."

Varnish or cement may be thinned with turpentine. If applied too thick, it will cause the transfer to slide out of position or wrinkle.

3. Wet the surface slightly with a sponge, and apply the transfer when sufficiently "tacky," being careful to lay it perfectly straight. Keep it from moving while pressing it in position.

4. A rubber roller, such as is used by photographers, is excellent for pressing the transfer in place. Start rolling it down from one end, or, if a very large transfer is applied, start from the center and roll toward

Fig. 332. Overlay transfer

the edges. Be careful to prevent air bubbles from forming under the transfer. If this happens, they should be worked gently toward the edges.

5. The heavy paper backing may now be removed by lifting a corner and peeling it off.

6. Allow the transfer to dry for a few minutes, and then wet the thin paper on the back with a sponge until it slides off easily.

7. Wash the gum deposits off the transfer with a sponge or cloth dipped in lukewarm water. Otherwise this deposit will dry and crack the transfer.

8. Remove the surplus cement around the edges of the transfer by sponging it with benzine or kerosene. The latter is recommended when the surface is painted in delicate colors.

9. A coat of varnish may be applied directly over the transfer after allowing it to dry for 12 hours.

10. If lacquer is to be applied, allow the same drying time; then apply a coat of white shellac, 2-lb. cut, which should dry at least 2 hours, and then the lacquer.

REVIEW QUESTIONS

1. Why should inlaying not be applied to coarse-grain woods?
2. What relation should the contours of overlays and veined work bear to the contours of the surface which they decorate?
3. How is inlay made commercially?
4. How are narrow bands inlaid by hand?
5. How are bands of inlay mitered in the corners?
6. Why should the inlay be allowed to dry 10 hours before it is scraped level with the surface?
7. Why are insets glued in place face down?
8. How may a turned column be divided into any number of parts?
9. How are straight reeds marked on a column?
10. How are spiral reeds marked on a column?
11. Why is it easier to carve spiral reeds than straight reeds?
12. How is a single spiral marked and carved on a turned cylinder?
13. What is "strapwork" carving?
14. Describe a method of making moldings by hand?
15. What advantage has a coped molding over a mitered molding?
16. How is a molding coped?
17. How are veneers cut and matched?
18. How may the pattern formed by matching veneers be determined before the veneer is cut?
19. How is veneer glued to a solid, flat board?
20. How is veneer glued to a curved surface?
21. What is the difference between overlays, frets, and veining?
22. Decalcomania transfers are a substitute for.....?
23. How are decalcomania transfers applied to a varnished surface?
24. Why should the cement or varnish applied to a decalcomania transfer be thin?
25. How is surplus cement around the edges of the transfers removed?

CHAPTER XV

UPHOLSTERY

253. History. The art of upholstery dates back to antiquity in Egypt and the Orient. In France, it reached a high degree of development during the reign of Louis XIV (1643-1715). In the same period of time, only loose cushions or pads were used in England, but when the monarchy was restored under Charles II (1660-85), real upholstered furniture and fine woven fabrics made their appearance. The revocation of the Edict of Nantes in 1685 was a great factor in this development, because the French protestants, called "Huguenots," many of whom were skilled craftsmen, emigrated in large numbers to England to avoid religious persecution. The Edict of Nantes was a guaranty of religious freedom to French protestants.

Upholstery, like wood finishing, wood turning, and wood carving, is one of the trades that is closely related to cabinetmaking, and in some measure dependent upon the latter. It is, therefore, fitting that this book should give some attention at least to the most elementary processes of this art, a knowledge of which will be found useful and valuable in the making of chairs, stools, and similar articles of furniture.

254. To Make a Plain Pad Seat. A pad seat is the simplest form of upholstery and, as the name implies, merely consists in making a pad or cushion on a wooden base. (Fig. 333.)

1. If the pad is to cover the entire board, except for a 1-in. margin along the edges, a line is marked accordingly all around the board.

2. Use tow for the stuffing; pick it carefully so that it is free from lumps, and spread half of it evenly over the seat to about ½ in. from the line marked.

3. It is important that the tow does not slide on the wooden base. It may be held in place either by tacking it to the base or by coating the base with glue before spreading the tow.

4. Distribute the rest of the tow evenly over the first layer, and stretch and tack a piece of muslin over it. Fold the muslin over on itself, and begin tacking it from the center of the four edges, gradually working toward the corners.

5. Place a piece of cotton wadding over the muslin, and then tack the covering in place.

6. Begin tacking from the centers of the front, back, and sides, driving the tacks only partly home. This is called "slip tacking."

7. Restretch the cover by stroking it from side to side and from

front to back. Pull out a few of the tacks at a time, and retack the cover firmly.

8. Make a gimp or narrow band of the same material as that of the covering. Gimps also may be bought ready-made. Tack the gimp in place, so that it is even with the line marked. Use metalene nails on

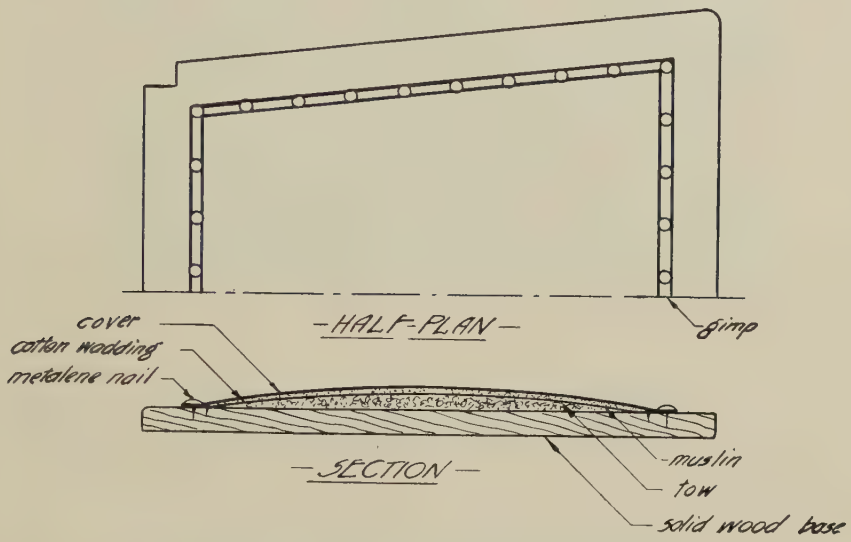


Fig. 333. Details of pad seat

leather or imitation leather, and gimp tacks on a cloth covering. Space the tacks from 2 to 4 in. apart.

9. The gimp is mitered in the corners by folding a pleat on it.

Tow is made from the dried stems of flax plants, which go through various picking and refining processes. Tow is sold to the trade in different grades of fineness. Muslin, wadding, and imitation leather are all products of the cotton plant. Muslin is a thin cloth which is sold either bleached or unbleached. Wadding or cotton felt is a by-product of the ginning process. Imitation or artificial leather consists of a strong woven cloth, which is dyed to the color of the finished product. It is then covered with nitrocellulose, which is a liquid also made of cotton. This forms a very strong and durable material used for many other purposes besides upholstery, as, for instance, suit cases, bookbindings, novelties, and automobile tops.

255. **To Make a Pad Seat with a Roll Edge.** This type of seat differs from a plain pad seat in that the covering extends over its outer edges. A roll of stuffing must be made to cover the sharp wooden edges in order to prevent them from cutting through the cover. A roll edge is formed as follows:

1. Tack a piece of burlap, about 3 to 4 in. wide, close to the outer edges of the seat so that the burlap projects beyond the seat. (Fig. 334.) Make a fold about ¼ in. wide on the edge of the burlap so that the tacks will hold better.

Fig. 334. Burlap for roll edge tacked to sides of seat

2. Use fine tow or moss for the stuffing. Place it along the edge and fold the burlap over it. Make the roll as hard and as even in size and shape as possible, and then tack the burlap in place. (Fig. 335.) If the burlap is cut straight, the lateral threads of the material will

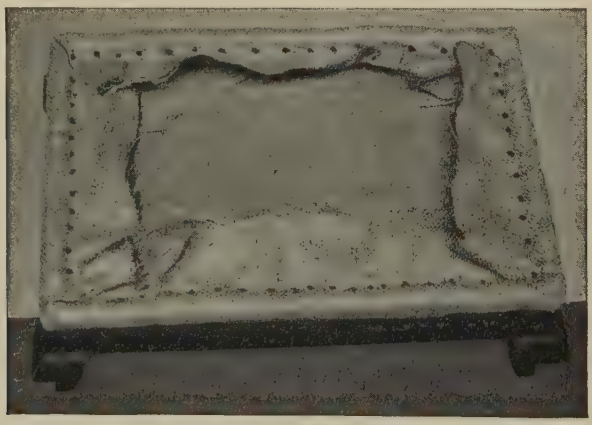


Fig. 335. Roll edge formed

act as a guide in forming the roll. The size of the roll varies with different conditions. For ordinary work, such as a seat on a footstool, a roll about 1 in. in diameter is suitable.

3. Proceed with the upholstery as explained in Article 254, steps 2 to 4.

4. Sliptack the muslin to the sides of the seat, or in the case of a footstool, to the rails near their lower edges. Restretch the muslin as explained in Article 254, step 7, until it is tight and smooth. Then tack it firmly in place folding the edge over on itself.

5. Place a piece of wadding over the muslin, and tack the covering and the gimp along the lower edges of the rails.

6. When the covering extends over the sides of the seat and is tacked to the lower edge of the rails as in the footstool, Figure 336, the corners must be folded or pleated in a certain way.

7. Stretch the covering well, and tack it along the lower edges of the rails to within 2 in. of the corners.

8. Fold the cover from the sides with the short rails over the front and rear corners, and tack it in place.

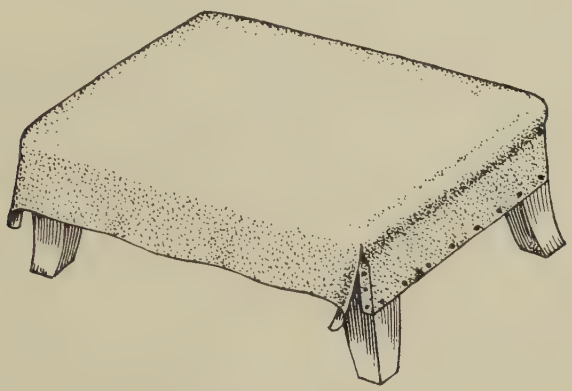


Fig. 336. Making pleats

9. Cut away the surplus material at the corners, fold a pleat on the front part of the covering, and fasten it with one tack so that it is even with the corner. Pleats on chairs are always laid to the rear.

Burlap is a coarse cloth, woven from the bast of the jute plant (Art. 288) which grows in India. It is used for a great many purposes, such as upholstery, draperies, bags for sugar, potatoes, and other products, as a base for linoleum, etc. Burlap is made in different qualities or weights. The pieces are generally 40 in. wide and 100 yds. long.

Moss is a plant which grows on the branches and trunks of trees. It grows abundantly in swampy regions in Louisiana, Florida, and South America.

Fresh moss is piled in small heaps kept moist with water. In the course of two or three months, the green covering rots away leaving only the black hairlike fiber. This is then dried, ginned, and baled. Moss is sold in different grades, according to the length of the drying time and the number of ginnings it has had.

256. To Upholster a Slip Seat. A slip seat fits tightly between the rails of a chair, bench, or stool. The seat, which may be upholstered or woven over a wooden frame (Art. 257), generally fits into a rabbet cut on the inside edges of the rails. It may also be supported and fastened to blocks or cleats screwed to the rails.

1. The frame of the seat is made of four pieces of wood ¾ to ⅞ in. thick and about 2½ to 3 in. wide. They may be joined by end-lap joints (Art. 159), dowel joints (Art. 156), or slip joints (Art. 167). Slip joints are the strongest and, therefore, preferred.

2. Join the pieces to conform to the shape of the seat as square, rectangular, or trapezoid. Allow from 1/16 to ⅛ in. for the covering on each of the outside edges of the frame, depending upon the thickness of the material. In other words, if the seat, for example, measures 12 by 18 in. within the rabbets, the finished outside dimensions of the frame

Fig. 337. Stretching webbing

should be 11⅞ by 17⅞ in. if 1/16 in. is allowed, and 11¾ by 17¾ in. if ⅛ in. is allowed.

3. After the frame has been glued, it should be smoothed with a plane. A chamfer, about 3/16 in. wide, should also be planed on the upper outside edges of the frame.

4. Begin the upholstery by nailing strips of webbing to the upper faces of the frame. For a chair-seat frame, two or three strips of webbing are used each way. Fold the webbing over about 1½ in. from the end so that the carpet tacks pass through two layers of webbing. Tack one end of a piece of webbing in the center of one of the rails and about 1 in. from its outer edge. Stretch the webbing over the opposite rail with the webbing stretcher (Fig. 337), and drive in three or four 10-oz. tacks. Release the stretcher, and cut the webbing with a pair of scissors about 1½ in. outside the tacks. Bend this end back over the tacks and fasten with a few more tacks. Fasten the other pieces of webbing in the same manner.

Pieces of webbing crossing each other should be interlaced for greater strength.

Like burlap, webbing is also made from jute fibers. Webbing is sold in rolls 72 yd. long. The standard widths are 3, 3½, and 4 in.

Fig. 338. Picking stuffing and placing it on frame. Notice burlap tacked over webbing

5. Cut a piece of burlap to about the size of the frame. Fold the edges over about ¾ in. all around, stretch and tack it to the face of the frame so that the webbing is covered. Use 4-oz. tacks.

6. Apply a layer of fine tow, or moss, about 2 in. thick, evenly over the face of the seat. (Fig. 338.) Pick it carefully with the fingers so that it becomes light and fluffy without any hard lumps.

Fig. 339. Sewing stuffing to webbing

7. Cut another piece of burlap a little larger than the frame, and stretch it over the layer of tow. Tack it temporarily to the edges of the frame without driving the tacks home. Now sew the burlap and tow to the webbing, using a long upholsterer's needle and twine. (Fig. 339.) First sew all around along the inside edges of the frame and then along the center. Have the stitches about 3 in. long come on top of the burlap, and pull them tight after complet-

ing the sewing. The tow and burlap are now held firmly, and the tacks temporarily holding the latter should be removed from the edge of the frame.

Thin three-ply veneer may be used instead of webbing. The processes in applying and sewing tow and burlap are the same. The upholsterer's needle is generally strong enough to go through thin three-ply veneer, but if the veneer should be too heavy for the needle, a few small holes may be quickly bored.

8. To form the edge of the seat, add some tow along the edge, shape it into a roll, pull the burlap over it, and tack the latter to the chamfered edge of the frame. Shape the edge of the seat so that it overhangs the edge of the frame a little and is of the same height as the part that was sewed to the webbing. When tacking the burlap to the frame, fold its edge toward the inside so that the outside is perfectly smooth.

9. Finish the corners last. If they have been cut to fit against the corner of a chair leg (Fig. 340), as is often the case, the edge must, of course, conform to that shape. The sharp peen of an upholsterer's hammer is very helpful in forming such corners.

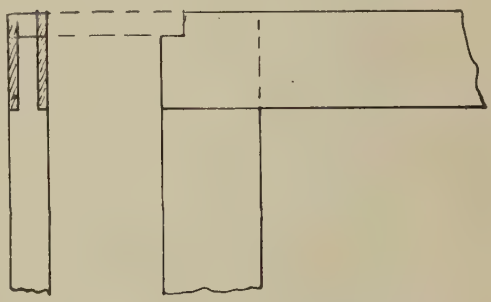


Fig. 340. Rear corner of chair-seat frame

10. The shape of the edge is now improved and made sharper by manipulating the tow with the regulator. (Fig. 341.) It is then sewed with a curved needle, so that the stitches, each about ½ in. long lie on top and below the edge, but do not pass over it. (Fig. 342.) The thread passes over the edge only in corners that fit around a square leg or post. This is done so as to make a sharper corner.

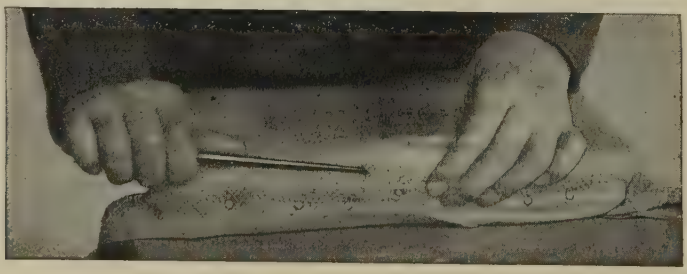


Fig. 341. Shaping edge with regulator

A curved needle is used instead of a straight one, because it goes in deeper and therefore pulls more material toward the edge.

11. A thin layer of moss or hair is next spread over the seat, so that it is made slightly higher in the center, sloping gently toward the edges. (Fig. 343.) A piece of muslin is stretched over this and fastened temporarily by slip-tacking or with large pins or skewers which are stuck into the upholstery just above the wooden frame. The muslin is then tacked to the edge of the frame, after which the pins are removed.

Fig. 342. Sewing edge with curved needle

If the seat is to be covered with silk, damask, or other thin material, a sheet of upholsterer's blue cotton wadding should be placed over the muslin to prevent the hair from sticking through the covering fabric.

12. The covering is tacked to the underside of the frame.

13. A piece of black cambric tacked to the underside of the frame will prevent dust from the upholstery material from falling to the floor.

Cambric is a cloth woven either of linen or cotton threads. Uphol-

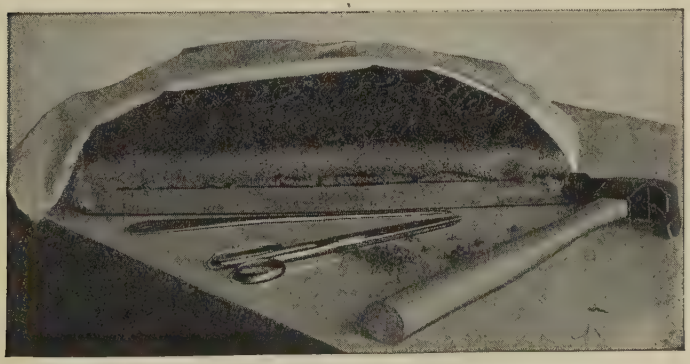


Fig. 343. Stretching and tacking muslin to edge

sterers use a cambric made of cotton. It is made only in two colors, white and black.

When a slip seat is made flush with the rails of a chair, the sewed edge may be omitted.

257. To Weave a Fiber Seat. Although rush weaving and caning has nothing to do with upholstery in the strict sense of the word, these processes are, nevertheless, used for the same purpose—the covering of a chair seat—and are, therefore, treated in the present chapter.

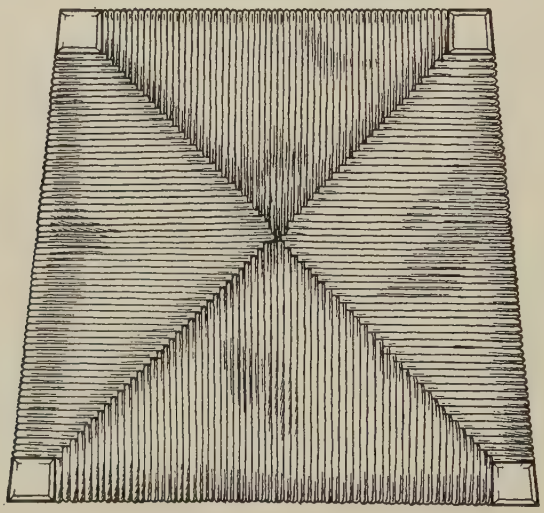


Fig. 344. Rush-woven slip seat

Woven seats for chairs, stools, and settees have been popular in this country since the first New England settlements. These seats were called "rush seats" or "flag seats," and were woven from a grasslike plant growing to a height of from 2 to 4 ft. The soft, pliant stems of these plants were dried and then twisted together to form the ropelike strands of the rush weave.

Rush seats are still made in the same manner, but it requires some skill to keep the strands properly twisted and of a uniform thickness. A new material called "art fiber," which consists of paper twisted into a rope of uniform thickness, makes a strong and good-looking seat, and is much easier to work with. This fiber is made in various thicknesses. A strand about $\frac{3}{16}$ in. or less in diameter is suitable for the weaving described in the following.

Fiber may be woven over the rails of a chair or stool, or over a loose frame to fit inside the rails of a chair. This loose frame is called a "slip seat." In any case, the outside sharp edges of the wood should

be slightly rounded so as not to cut the fiber. On a fixed seat, the legs should extend as much over the rails as the thickness of the fiber. (Fig. 345.) On a slip seat, a block of the same thickness as the fiber should be glued to the top of the frame in each corner. (Figs. 344 and 346.) In both cases, the weaving should be flush on the edges with the legs or corner blocks. The rails should, therefore, set back from the corners for a distance equal to the thickness of the fiber. The weaving is done as follows:

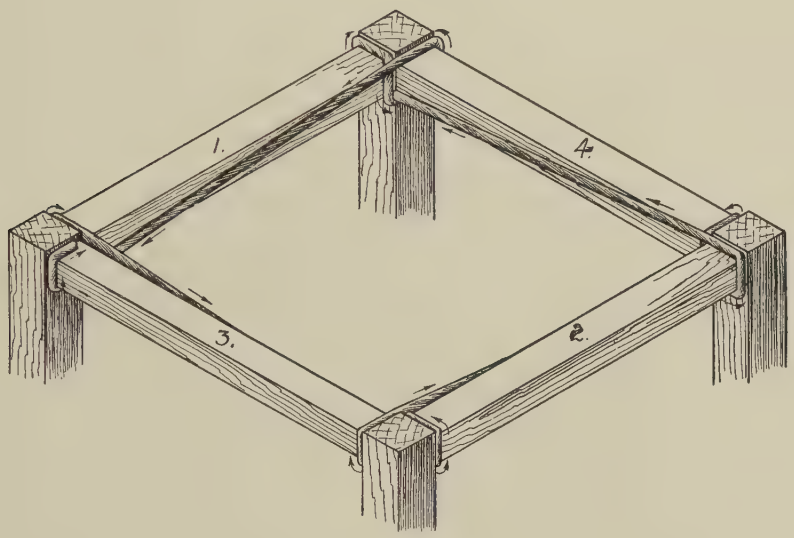


Fig. 345. Weaving square rush seat

1. Cut a few yards from the roll of fiber and tack one end of this to the underside of the rail numbered 1. (Fig. 345.)

2. Bring the length of fiber back and up over 1, under 2, back over 2, under 3, over 3, under 4, over 4, under 2, over 2, under 1, over 1, under 4, over 4, under 3, over 3, under 1, and so on until the seat is completed.

3. Keep each succeeding strand as close to the previous one as possible and be careful to pull them as tightly as you can.

4. This weave forms two diagonal lines which cross in the center on a square seat. Take care to get these lines straight. If necessary, hammer the fiber in place by driving on a block of wood held against any strand which is out of line.

5. Join a new length of fiber to the one with which you are weaving by tying a square or reef knot. This knot, of course, should always come on the lower side of the seat.

6. It is well to stuff pieces of soft paper in between the upper and lower strands of fiber so as to make the seat more solid.

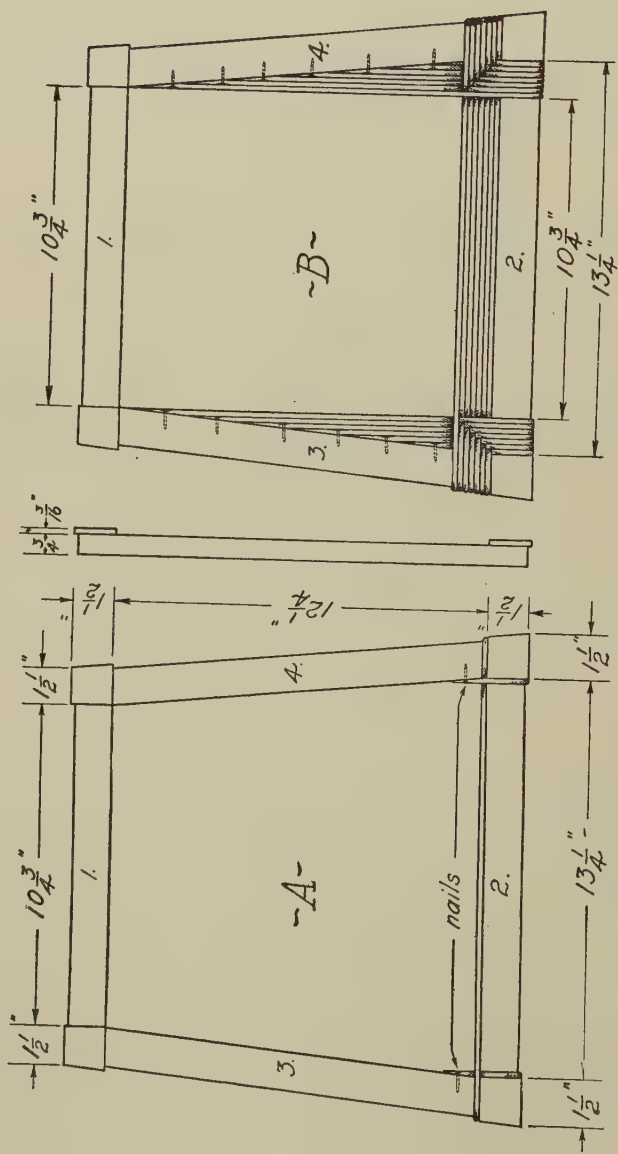


Fig. 346. Rush weave on slip seat wider at the front. A, One strand woven and tacked in place. B, Filling in front rail

7. When finishing the seat, use a sharpened dowel to force the strands apart in the center in order to make room for the last strands.

When the seat is wider at the front than at the rear, such as the chair seat shown in Figure 344, this extra width is filled in as follows: Tack the end of a strand of fiber to the inside edge of side rail No. 3 near the front corner. (Fig. 346, A.) Bring it under front rail No. 2, back over 2, under 3, over 3, under 4, over 4, under 2, over 2, and then nail it to the inside edge of side rail No. 4 near the front corner. Cut off the end above the nail, weave another strand and continue in this manner until the distance between the woven strands on the front rail equals that between the blocks on the rear rail. (Fig. 346, B.) Then tack a strand to the underside of the rear rail No. 1 and continue the weaving as explained above. (Fig. 345.)

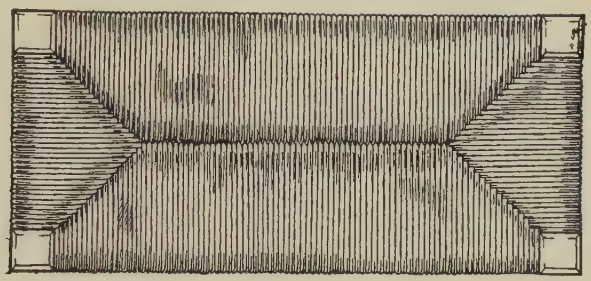


Fig. 347. Rectangular rush-woven seat

When the seat is rectangular, such as that shown in Figure 347, the weaving is done as explained above until the two short rails are completely covered. The fiber is then woven back and forth between the two long rails until these are also covered.

8. It is recommended to give fiber seats a coat of glue sizing in order to make them waterproof. They may then be varnished or lacquered as desired.

Fiber is made in many different colors. Follow manufacturers' directions as to finishing.

258. To Weave a Cane Seat. Cane is made from the bark of a palm, which grows in the Philippines and other East Indian countries. This bark is stripped from the trunk by machinery, after which it is cut into narrow ribbons called "cane." Cane is graded according to the different widths into which it is cut, as superfine, fine-fine, fine, medium, coarse, and binding.

1. The frame for a cane seat is made in the manner explained in Article 256.

2. The holes for the cane are bored about $\frac{5}{8}$ in. from the inside edges of the frame. For fine cane, the holes should be $\frac{5}{32}$ in. in diam-

eter and spaced ½ in. center to center. For medium cane, the holes should be 3/16 in. in diameter and spaced ⅝ in. center to center.

3. Mark a pencil line all around the frame ⅝ in. from its inside edges. Mark the center point of each member of the frame on this line, and lay out the centers of the holes from these points.

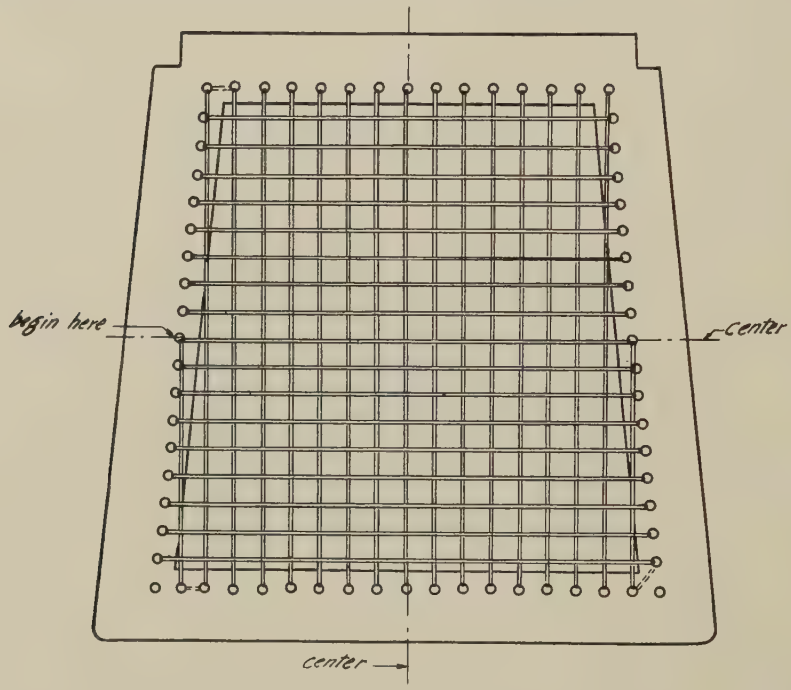


Fig. 348. Caning a chair seat; two single strands woven

4. Notice that there are four holes more in the front rail than in the rear rail. (Fig. 348.) To overcome this difficulty, start the first strand of cane in the center hole in one of the sides, and bring it down through the second hole in the front rail. Then draw it up through the third hole in the front rail, and down through the corner hole in the rear rail, and so on, until a row of parallel strands is stretched between the front and rear rails. (Fig. 348.)

5. Now weave a similar row of strands between the two side rails. This row of strands will cross the first row at right angles. (Fig. 348.)

6. When a strand is used up, its end is looped around the weave running between the holes on the underside of the seat. A new strand is fastened in a similar way. A couple of round, wooden pegs, fitting into the holes of the frame, will serve to hold the cane during the weaving process.

7. After completing the weaving of the single strand between the sides, repeat the weaving between the front and rear rails, drawing the cane through the same set of holes. The single strand woven from side to side, therefore, passes between the two strands woven from front to rear.

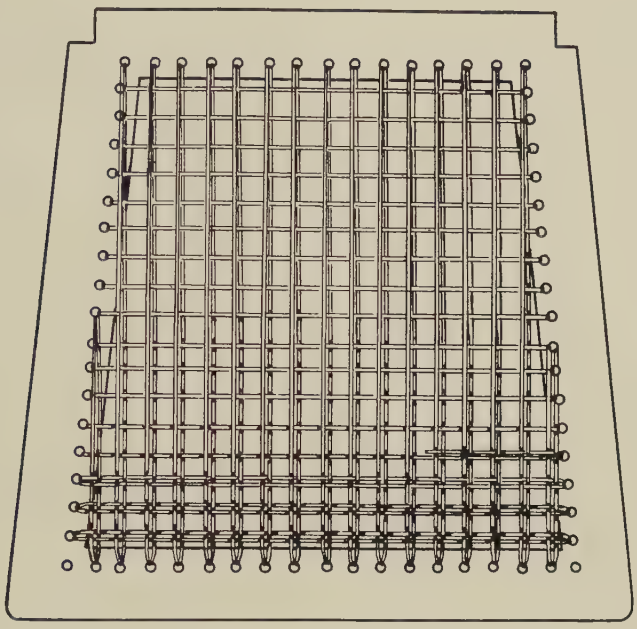


Fig. 349. Caning a chair seat; fourth strand being interlaced between first and third strands

8. A fourth strand is now woven from side to side, and interlaced between the first and third strands as shown in Figure 349.

9. The weaving is completed with two diagonal strands crossing each other at right angles. (Fig. 350.)

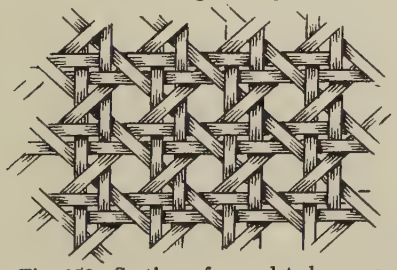


Fig. 350. Section of completed weave

10. A piece of coarse cane, called "binding cane," is usually fastened along the edge of the weaving. Very fine cane is used to bind it.

An awl, a tool resembling an ice pick in shape, is useful in forcing the weaving together in the holes, so that new strands may be inserted.

259. To Apply Cane Webbing. Weaving cane by hand, as explained in Article 258, is a slow and tedious process. Caning is, therefore, often done with machine-woven cane, called "cane webbing."

Cane webbing is manufactured in widths of 10, 12, 14, 16, and 18 in., and is sold by the yard. Open-woven cane resembles the weaving done by hand. Close-woven cane is the kind commonly used on seats of street and railroad cars. Cane webbing is quickly and easily applied, and it looks just as well as hand-woven cane.

1. Cut a groove ¼ in. wide by ⅜ in. deep along the inside edges of the seat frame to be caned. The distance from the edges to the groove should be about ⅝ in. If the grooves are straight, they may be cut on the circular saw, but if they are curved, they must be cut on a shaper or boring machine, using a router bit.

2. Cut the cane sheets, so that they are at least 1½ in. larger than the distance between the outside edges of the grooves. This will allow ¾ in. of cane on each side for driving into the grooves.

3. Soak the sheet of cane in water for at least one-half hour, and in the meantime prepare a board which will fit over the inside edges of the frame without covering any part of the grooves.

4. Run hot glue into the grooves, and place the wet sheet of cane over the frame, so that it projects equally over the grooves on all four

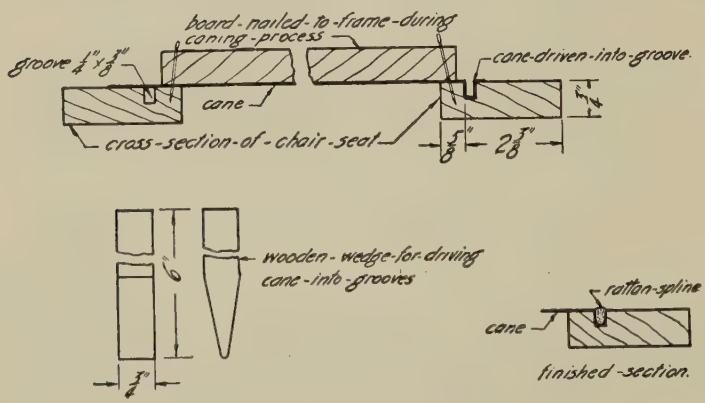


Fig. 351. Applying cane webbing

sides. Place the board over the cane, and fasten it with a fine brad to each of the rails. (Fig. 351.)

5. Drive the cane into the grooves with a wooden wedge, shaped like a ¾-in. cold chisel, but with a rounded point. (Fig. 351.)

6. Run more glue into the grooves and drive the splines in halfway. Splines made of rattan are used especially on curved grooves. On straight grooves, wooden splines may also be used.

7. Cut away the projecting ends of the cane before driving the splines in all the way. This may be done by running a sharp knife or chisel along the outside edges of the spline.

8. Drive the splines in all the way, using a small block of wood to protect them from being marred by the blows of the hammer.

9. When the cane dries, it will contract, thus making the seat very tight.

REVIEW QUESTIONS

1. How is the stuffing of a pad seat kept in place?
2. What is understood by slip-tacking?
3. How is imitation leather manufactured? For what is it used?
4. What is the purpose of a "roll edge"? How is it made?
5. What is moss? How is it prepared for the upholstery trade?
6. What is a slip seat? On what type of chairs is it mainly used?
7. What type of joints may be used for the frame of a slip seat? Which is the strongest?
8. What is webbing made from? For what is it used?
9. How is the stuffing held in place on a webbing base?
10. What is a regulator? How is it used?
11. Why is a curved needle used in sewing an edge?
12. Under what covering material should cotton wadding be used? Why?
13. What is a rush seat? For what is it used. Of what material is it made?
14. How is cane manufactured?
15. How are the holes laid out for a hand-woven cane seat?
16. Why should the difference in the number of holes between the front and rear rails always be an even number?
17. What is cane webbing? How is it fastened to the seat of a chair?
18. Why is cane webbing soaked in water before it is applied to the chair seat?
19. What may be used instead of rattan splines?
20. Why is a board placed over the cane webbing while it is being driven into the grooves?

CHAPTER XVI

WOOD FINISHING

Wood finishing is the last step in the completion of a piece of furniture, and a very important one. It was formerly a part of the cabinetmakers' trade, but now requires so much skill and knowledge that it has developed into a distinct trade. During the last decade or two, a great many discoveries, both chemical and mechanical, have made this trade one of the most important specialties in the furniture industry.

While nowadays the professional cabinetmaker seldom "finishes" a piece of work himself, yet it is important that he should know something about finishing methods. To the student and nonprofessional woodworker, this subject should be of particular interest.

Modern methods of finishing are too numerous and complex to be treated in this volume. Only the simplest and most common will, therefore, be described in the following.

Wood finishes are either transparent or opaque. The finishing processes of the first type, with which we are principally concerned, fall into three main divisions: staining, filling, and polishing.

Opaque finishes are produced by paints, colored lacquers, or metallic leaf or powders.

261. To Prepare the Surface. While the different parts of a piece of furniture should be prepared for finishing during the process of construction, especially those that are inaccessible after gluing, it is, nevertheless, of the utmost importance to give the piece a thorough inspection when all the toolwork has been completed, so that any little damage or defect may be repaired. Check the following points:

1. See that every trace of glue is removed from around the joints, because stain does not penetrate through glue. Any speck of glue, therefore, leaves a light mark on the stained surface. Use the blade of a cabinet scraper or a chisel, with the edge bent over, to remove glue from corners that are not easily accessible.

2. Inspect the surfaces thoroughly for any dent or bruise. A dent in the wood often may be removed by the application of a small pad of cotton waste soaked in hot water. Leave the pad on the bruise for a few seconds, and repeat. The water will fill the cells in the wood near the surface and cause them to swell, thus bringing the bruise to the level of the surrounding surface.

3. Inspect the surface for any marks left by the veneer scraper or any scratches from sanding across the grain. Nothing shows up more

prominently and is more unsightly when the finish is applied than scratches across the grain. It is usually necessary to use a scraper to remove them entirely, and then resand the surface.

4. See that there are no spots of oil or grease on the surface, because they will prevent the stain from penetrating. They should be removed by rubbing with naphtha or benzine.

5. Any holes, cracks, or other defects should be filled with crack filler, which is also known as wood cement or stick shellac. It is sold in sticks of different colors, and is composed largely of shellac and resin. It is melted into the hole to be filled like sealing wax, or by holding a piece of heated iron against it until the drops melting off fill the crevice to above the level of the surface. Work it in with the hot iron. It hardens in a moment, and should then be cut down almost to the level of the surface with a very sharp chisel or scraper. Finish with sandpaper until the surface is perfectly level and smooth. When the color of the finish is to be matched exactly, this should be done after the first finishing coat has been applied.

6. Give the piece of furniture to be stained a final but thorough sanding, using No. 2/0 sandpaper. Hold the work toward the light, and see that no imperfections remain on the surfaces. If water stain is to be used, wet the work before this final sanding. (Art. 262.)

Too much care cannot be given to this final preparation and inspection for, contrary to the popular belief, imperfections in the surface are not covered by the finish. Rather, they appear as if magnified. An extra hour spent in preparing the surface for staining is, therefore, well spent, and often saves many hours of tedious refinishing.

STAINS

The purpose of staining usually is to produce on freshly-cut and seasoned wood a rich and mellow color. Oftentimes certain species of wood are stained to imitate others more costly, provided their grain and texture are similar. Many species of wood, for example, are stained to imitate mahogany or black walnut. Furniture stained with this end in view is labeled by the honest manufacturer as "mahogany finish" or "walnut finish," as the case may be. In any case, stains are always transparent and do not obscure the grain of the wood.

Stains are classified according to the material of which they are made. The following are the most common:

262. **Water stains** are made by dissolving powdered aniline colors in *hot* water. They are clear, penetrate deeply, and do not fade. As they are also inexpensive, they are widely used at the present time, especially on high-grade work. The only disadvantage in using water stains is that they raise the grain of the wood. This is overcome by sponging the wood with water, and sanding it again after drying. The

stain should be applied cold, brushed dry, not wiped, and allowed to dry for about six hours.

263. **Spirit stains** also are made from aniline colors, but the solvent used is alcohol. They dry so rapidly that it is difficult to cover a large surface without showing laps or streaks, except with an air brush. They are used chiefly for shading and for refinishing old work, because they penetrate more readily than water or oil stains. They are liable to fade when exposed to the light.

264. **Oil stains** are made by dissolving oil aniline colors in turpentine, benzine, or benzol. Asphaltum and naphtha also are among the ingredients of these stains. They usually are bought ready-made, and are very easy to apply because they take a longer time to dry. They fade or change color when exposed to the light. Oil stains should be wiped dry with a piece of cotton waste as soon as they begin to show streaks and become flat. Allow 24 hours for drying.

Aniline and benzine are coal-tar products; naphtha is distilled from petroleum; asphalt is a mineral pitch found around oil wells, and turpentine is an oil produced from the sap of long-leaf pines.

265. **Acid stains or stains due to chemical action** were used a great deal in former years, but are very seldom used commercially at the present time. They are dangerous to use, and do not produce as good results as the more modern water stains.

Some of the most common acid stains are as follows: *Bichromate of potassium* dissolved in water gives oak and mahogany a brownish color. Oak and mahogany contain tannic acid which reacts with the bichromate of potassium.

Permanganate of potash dissolved in hot water also produces brown shades of color on oak. A strong solution of *ammonia* allowed to evaporate in a small closed room or box produces a rich brown color on oak called "fumed oak."

Quicklime dissolved in water gives a rich reddish color to mahogany, and is of value for this purpose, because it does not affect the color of inlays. It is applied with a brush. When dry, the surface looks like it had been whitewashed. It should be wiped off with burlap or cotton waste. A coat of boiled linseed oil, thinned with turpentine, will remove the last traces of the lime. This should invariably be applied before the wood filler.

266. **General Directions for Staining.** (1) Brush with the grain, and apply the stain rapidly and evenly.

2. Finish all inside surfaces before staining the outside surfaces.
3. Stain all removable parts, as drawers or doors, separately.
4. Brush along the entire length of a surface to prevent laps.
5. After dipping the brush, begin on the unfinished part, and brush toward the finished part.
6. Regular stain should be applied to sapwood parts, and allowed

to dry before the general staining. This is because sapwood is generally lighter than heartwood, and needs a second coat to make the staining uniform.

Supplement these general directions for staining by consulting information on specific stains.

267. To Apply Wood Filler. Wood filler is used for filling the pores of open-grain woods like oak, chestnut, ash, walnut, mahogany, etc., so as to produce a perfectly level and smooth surface.

It is manufactured in paste form, and consists of silex ground in japan, linseed oil (Art. 272), and turpentine. The natural color of filler is a light cream, but any color may be obtained by the addition of colors ground in oil or japan.

Silex or silica is a white powder consisting of quartz and sand.

Japan is a drying agent made from various gums, shellac, linseed oil, metallic oxides, and turpentine.

Filler is usually applied after the stain and in a corresponding color. Sometimes, however, filler is used as a stain, especially on dark woods, by coloring it a little darker than the wood. Two-tone effects can be produced by using a lighter and a darker shade of filler.

1. Take a quantity of paste filler from the can, add a little turpentine, and stir the mixture with a wooden stick, shaped like a paddle, until it has become a homogeneous mass. On oak, 1 lb. covers about 30 sq. ft. Add small quantities of turpentine at a time, and mix well until the filler has the consistency of thick cream or soup. The coarser the grain of the wood to be filled, the thicker the filler should be.

2. Brush it on with a fairly stiff bristle brush, so that it is worked well into all the pores.

3. When the filler, which was first applied, begins to look flat, stop putting on more filler and begin wiping off with some material that does not lie flat on the surface. Coconut hair, sea moss, fine excelsior, burlap, or cotton waste are all useful for this purpose. Wipe first across the grain so as not to lift part of the filler out of the pores. Finish by wiping lightly with the grain, using a clean soft cloth or cotton waste until a clear, smooth surface is produced. If the filler is hard to wipe off, moisten the wiping cloth slightly with turpentine.

4. Stir the filler well before resuming the brushing-on process, because the heavier parts of it will settle to the bottom of the can, leaving only the turpentine on top.

5. Remove surplus filler as before, using a pointed wooden stick to clean out corners, recesses, and other irregular surfaces. So far as possible, all surfaces should be filled in a horizontal position, as this gives the best results.

6. Usually 1 coat of filler is sufficient. Allow 24 hours for drying Close-grain woods, such as maple or birch, are generally given a coat of shellac instead of filler.

FINISHING COATS

268. To Apply Shellac. Shellac is produced by insects called "lac bugs," native to India. These insects extract the sap from the young twigs of certain species of trees, and secrete a fluid which hardens and covers them and the little twigs completely. The twigs are gathered and separated from the hard substance, which is melted and refined, and is known as "shell-lac."

Orange shellac is the natural product. White shellac is produced by bleaching orange shellac.

Stock shellac usually consists of 4 lb. of shellac gum dissolved in 1 gal. of alcohol, and is known to the trade as "4-lb. cut."

1. Prepare the first coat by adding from 25 to 50 per cent of alcohol to the stock solution.

2. As shellac dries very rapidly, it is difficult to brush it on evenly. Use a rubberset brush with medium-size bristles. Start from the top of a piece of furniture working downward. Be careful not to let the shelac run on the edges. Pick up such runs immediately with an almost dry brush. The brush strokes always should be with the grain, and doors and drawers should be removed and brushed separately.

3. Allow from 2 to 4 hours for drying, and then rub down with No. 2/0 steel wool, or very fine sandpaper. Steel wool is preferable, because the sandpaper "gums up."

4. Apply succeeding coats in the same manner, rubbing down between coats. Each succeeding coat should contain more shellac and less alcohol. They are, consequently, heavier and more difficult to apply.

5. After 3 or 4 coats, the final rubbing down is done with No. 2/0 steel wool, or very fine sandpaper.

6. Finish rubbing with FF powdered pumice stone and rubbing oil. Always rub with the grain, as fine scratches produced by rubbing across the grain are very noticeable. Clean off the surface with cotton waste and benzine.

Shellac should not be applied over a spirit stain as it dissolves the color, thus giving the finish a muddy appearance.

Shellac has the advantage over varnish due to the fact it does not crack. A "French polish" is produced by applying thin films of shellac with a pad. It is a process that takes a good deal of time and requires great skill. It is used very much in Europe, but not in this country. Wax is often used over shellac as a polish. For the best results, the shellac should be smoothed with No. 2/0 steel wool before the wax is applied.

269. To Apply Lacquer. Lacquer is one of the newest products of the finishing industry, being only a few years old. It is composed of many chemicals, some of the most important being nitrated cotton, banana oil, alcohol, naphtha, shellac, or varnish gums.

Banana oil is a complex chemical substance, technically known as amyl acetate. It has many advantages, such as drying quickly, withstanding heat or cold, and not cracking easily. It is difficult to apply, however, and cannot be used over oil stain, varnish, or paint, because it contains some of the ingredients used in varnish and paint remover, and, consequently, dissolves these undercoats. A sealing coat of thin shellac should be brushed over ordinary wood filler if a lacquer is to be used. A special filler, which can be used directly under lacquer, has recently been put on the market. Both clear and colored lacquers are manufactured.

1. Use the lacquer as it comes out of the can, unless it is too thick to flow freely. Brush it on with a soft fitch or camel's hair brush. Do not brush over the same place twice. Work rapidly, and follow the directions given for applying shellac in Article 268.

Lacquer should be thinned only with special thinners sold by the manufacturers of the lacquer. These thinners *should not be interchanged,* but should be used only with the brand of lacquer for which they are made.

2. It is not necessary to sand between coats except to remove imperfections, as each coat of lacquer makes a perfect bond with the preceding one. Two or three coats should be sufficient. Allow from 4 to 6 hours for the last coat to dry.

3. A lacquered surface may be rubbed down with steel wool, but more quickly with No. 5/0 waterproof sandpaper. Rub with the grain, using plenty of water under the sandpaper. This paper cuts very fast and little pressure should, therefore, be used.

4. Wipe off the surface with a sponge and a chamois skin, and inspect it frequently.

5. When the gloss has been removed, the rubbing should be continued with FF pumice stone and clear rubbing oil. A pinch of pumice stone is sprinkled on the surface, and the felt rubbing pad is dipped in the oil. Begin with a gentle pressure until the pumice and oil have been well distributed over the surface. Be careful about the edges, as beginners are very likely to rub through the finish on the edges. Rubbing oil should be used only on the last coat of lacquer.

270. **To Apply Varnish.** Varnish consists of copal gums dissolved in linseed oil. It is thinned by adding turpentine. Varnish is made in many grades and for different types of work. A good rubbing varnish suitable for cabinetwork should be transparent, dry hard, and be able to resist heat.

Varnish produces a beautiful finish, and is used on the highest grade of cabinetwork. The disadvantages in using this finish, however, are that it generally cracks and becomes dull and very ugly with age, and that a special, dustproof finishing room is necessary.

Copal gums are fossilized resin deposits from pine trees long since

dead. They are found buried in the ground in certain parts of Africa, New Zealand, East and West Indies, and South America.

1. Varnishing must be done in a dust-free room. One cannot be too particular in removing dust from one's clothing, before entering the room, sprinkle water on the floor, and brush off the article of furniture to be varnished. A rag moistened with turpentine is the best thing with which to remove the last vestige of dust from the surface to be varnished.

2. Varnishing should be done at a temperature of about 80 deg. The varnish should be used as it comes from the can. Thinning may cause it to lose its luster. It may be heated by placing the can in a pan of hot water to make it flow more freely. It may be applied directly over the filler, or an undercoating such as shellac may be used.

3. Unlike shellac and lacquer, varnish is easy to apply, because it dries slowly. Care should be taken, however, to spread it evenly so as to prevent piling up, runs, and sags. Finish with long, light, feathery strokes with the grain.

4. Allow from 24 to 48 hours or more for drying; and sand in between coats. This is necessary in order to get a good bond between coats. Varnish does not adhere to a glossy surface. If waterproof sandpaper is used, the dust produced by rubbing with ordinary sandpaper or steel wool is avoided. Allow 2 hours before applying the next coat, if water is used in rubbing. (See directions given in Art. 269.)

5. A satin finish is produced with FF powdered pumice stone and rubbing oil, as described in Article 268, step 6.

6. A higher polish is produced by adding rottenstone to the pumice, or by rubbing with only rottenstone and oil.

7. Clean the rubbed surface, and finish by rubbing it with polishing oil.

8. The surface is given a final cleaning by rubbing very lightly with a linen cloth wrapped around a small piece of waste moistened with alcohol. Rub quickly, and never let the ball rest on the surface as the alcohol will burn through the finish. This process is called "spiriting off" and is also used when finishing a "French polish." (See last paragraph in Art. 268.)

271. **To Apply Wax.** Wax is composed chiefly of beeswax, paraffin, carnauba wax, and turpentine. Carnauba wax is the best and hardest kind of wax, and is extracted from the leaves of a tree native to South America.

Some waxes are manufactured in paste form, but more modern waxes are manufactured in liquid form.

1. Before a surface is ready for waxing, it must be filled and given a sealing coat of shellac, varnish, or lacquer. If a sealing coat is not given, the wax penetrates into the wood, leaving a dull, uneven finish.

2. Apply the wax, either paste or liquid, with a soft cloth. Do not

put too much on at a time, as it is likely to make the surface greasy and consequently difficult to polish.

3. Allow the wax to dry for about 20 minutes, and then rub briskly with a soft cloth. Finish rubbing with the grain.

4. A second coat may be applied after an interval of 1 or 2 hours.

272. **To Apply Linseed Oil.** Linseed oil is produced by subjecting flaxseed to pressure. The raw oil is very fatty, and dries slowly. Raw oil is used in outside paint. Boiled linseed oil is produced by boiling the raw oil with certain chemicals. Many of the fatty substances which retard the drying qualities of the oil are removed by this process. As boiled linseed oil, therefore, dries faster than raw linseed oil, it is used principally on inside work. Linseed oil dries by oxidation; i.e., contact with the air.

1. Boiled linseed oil, thinned with from 2 to 3 parts of turpentine, is applied with a brush or rag directly over the wood filler. The best results are obtained by letting the filler dry 48 hours. Put plenty of oil on the surface, and allow it to soak into the wood for about half an hour.

2. Rub hard and vigorously with a dry, clean cloth, being careful to rub each part of the work absolutely dry. If this is not done, the surface becomes sticky and must be cleaned with turpentine.

3. Allow 24 hours between coats. At least 3 or 4 coats are necessary. This treatment produces a soft sheen, and brings out the color and grain in the wood.

Be careful about the disposal of rags soaked in linseed oil, as spontaneous combustion is likely to occur.

273. **Summary of Advantages and Disadvantages of the Finishing Coats Described.** *The shellac finish* is beautiful, hard, and durable, but it is somewhat difficult to apply by hand methods. No dustproof finishing room is necessary.

The lacquer finish is very transparent, lustrous, and beautiful. It is also hard and durable, and does not mar easily. It is rather difficult to brush on, but improvements in manufacturing processes are constantly being made to overcome this difficulty. As it dries quickly, no special dustproof finishing room is needed. This is a distinct advantage over varnishing.

The varnish finish is also clear and beautiful, but it is very easily marred, cracks, and becomes dull and ugly with age. It is easy to apply, but great care must be taken to keep the work free from dust. It is used commercially on all fine furniture, pianos, radio cabinets, etc.

The wax finish is very easy to apply, and very easy to repair. It is not durable, however. Finger marks show plainly, and any liquid spilled on it makes a dull spot. It is recommended for beginners on account of the ease with which it is applied.

The oil finish is not so brilliant as the shellac, lacquer, or varnish,

but it is very durable and gives furniture a certain charm and quiet dignity, characteristic of antique pieces. Oil finishing was used a great deal on the earlier antiques. It is not used commercially, but is to be recommended for students and amateur woodworkers.

TO PAINT FURNITURE AND INTERIOR WOODWORK

The process of applying inside paint may be divided into the following general steps: preparation of the surface for the priming coat; application of the priming coat; filling of holes and other imperfections in the surface; application of second and third undercoats, and application of the finishing coats.

274. **Preparation of the Surface.** (1) The surface must be perfectly smooth, well sanded, and free from grease or glue spots. (Art. 261.)

2. Soft woods like basswood or whitewood should be given a coat of thin shellac before the priming coat is applied. The shellac will prevent the wood from absorbing the oil in the paint too rapidly. It will also stiffen and bind the very fine fibers of such woods together, so as to eliminate all fuzziness and produce a perfectly smooth surface when sanded. Sand lightly with No. 2/0 sandpaper before applying the priming coat.

3. Pitchy woods, such as yellow pine, should also be given a coat of thin shellac in order to prevent the pitch from penetrating, or bleeding through, and discoloring the various coats of paint. Sand the coat of shellac as explained in step 2.

4. Porous woods, such as chestnut, oak, and ash, should be given a coat of paste wood filler before the priming coat is applied. (Art. 267.)

5. Hard, close-grain woods, such as birch or maple, need no further preparation beyond smoothing and sanding. The priming coat may be applied directly to such woods.

275. **Application of the Priming Coat.** The chief ingredients of inside paints are white lead or zinc white, boiled linseed oil, and turpentine. To a priming coat is generally added French yellow ocher, a claylike substance, ground in oil, because it covers the surface better.

Primers, paints, and undercoats can be bought ready mixed, and will prove very satisfactory. If it is desired to mix the primer from the raw materials, the following procedure is recommended:

1. Mix some yellow ocher together with the needed quantity of white zinc. The amount of ocher to be mixed with the white zinc depends upon the darkness of the finished color. If the finished color is to be white, no ocher should be used.

2. Add about a tablespoonful of boiled linseed oil to each quart of zinc, and work it thoroughly together. Then add about one gill of turps and ¼ gill of japan drier to each quart of zinc white, and mix

thoroughly. If this mixture is too thick, add boiled linseed oil to it until it has the consistency of cream.

It is very important to take time to mix the ingredients thoroughly, because the quality of the paint, and therefore the finished product, depends upon how well this preliminary work is done.

Zinc white and white lead are both metallic compounds derived respectively from zinc and lead. As white lead is poisonous, it is recommended to use zinc white in its place.

3. Apply the primer and let it dry from 12 to 24 hours; then sand lightly with No. 0 sandpaper until all brush marks have been obliterated and a smooth surface is produced.

276. Filling Holes and Other Imperfections in the Surface. After the priming coat has been applied, any imperfections in the surface will be more noticeable. (See last paragraph in Art. 261.) These should be filled with a good putty or with Danish whiting mixed with some thin glue. The latter type of putty will dry very hard in a few hours, and will not crack nor shrink if properly mixed. It should be applied with a putty knife and, when dry, sanded with No. 2/0 sandpaper. Nail holes may be filled by using the fingers instead of the putty knife.

Whiting is white, powdered chalk, which is also used as a pigment. Several preparations of this kind are on the market.

277. Application of the Second and Third Undercoats. Prepare the second coat from the original mixture of zinc white and ocher, but thin only with turpentine, adding a little at a time. Apply this coat, and allow it to dry from 12 to 24 hours before sanding.

For the third coat, which is often unnecessary, use pure zinc white. Add the desired color pigment ground in oil and 1 tablespoonful of turps to each quart of zinc white. Stir the mixture thoroughly. Then add a little japan drier and enough turps to give it the right consistency. Apply as before, and allow 24 hours for drying. Sand lightly with No. 2/0 sandpaper.

Ready-mixed paints and undercoats of a good grade will also give satisfactory results. They should be applied according to the directions given by the manufacturer.

278. Application of the Finishing Coats. The finishing coat generally consists of enamel, which is a colored varnish. Enamel is more transparent than paint, and does not cover the wood so well. For this reason, paint is used for the undercoats, the last of which should be of the same color as the enamel. Enamel, like paint, may be bought to finish either flat or glossy.

1. The first finishing coat should consist of equal parts of enamel and paint used for the last undercoat. Let this dry for 36 hours. Then sand with No. 3/0 sandpaper, and wipe the surface with a piece of moist chamois skin so as to remove every particle of dust.

2. The last coat should be pure enamel just as it comes from the can. Like varnish it should be applied in a dustproof room, at a temperature of from 70 to 80 deg. (Art. 270.)

3. Good enamels dry slowly. It is, therefore, best to let the work stand 4 days before rubbing it down with pumice stone and water.

REVIEW QUESTIONS

1. How can a small dent in a finished surface be removed without replaning the whole surface?
2. In preparing a surface for a transparent finish, which defects should be particularly guarded against?
3. What are the advantages of water stains over oil stains and spirit stains?
4. Under what conditions would it be advantageous to use quicklime to stain mahogany?
5. Why are oak and mahogany particularly sensitive to acid stains?
6. What precautions must be taken in staining sapwood?
7. What are the chief ingredients of paste wood filler?
8. How can surplus filler be removed from a surface if it has become so hard that it cannot be wiped off by ordinary rubbing?
9. How is shellac made commercially?
10. Why is steel wool preferable to sandpaper in rubbing down a shellacked or lacquered surface?
11. What are the principal advantages of lacquer over varnish?
12. Why cannot lacquer be applied directly over ordinary paste wood filler or paint?
13. What is copal gum? Where is it found?
14. Why is a dustproof finishing room necessary for producing a good varnish finish?
15. Why must varnish be sanded between coats?
16. Describe the procedure in rubbing down a varnished surface.
17. From what is linseed oil made? How does it dry?
18. Why should rags or waste used for applying linseed oil be carefully collected and destroyed?
19. What are the advantages and disadvantages of a wax finish?
20. What types of lumber should be given a thin shellac coat before the priming coat? Why?
21. How are porous woods treated before the priming coat is applied?
22. What are the chief ingredients of inside paint?
23. How are nail holes filled?
24. What is ocher and why is it used in the priming coat?
25. What is the difference between paint and enamel?

CHAPTER XVII

WOOD

It seems but natural and reasonable that the woodworker should have at least an elementary knowledge and understanding of "wood," the principal material with which he works.

Such information will make him more intelligent by increasing his knowledge of the world about him, and it will give him certain scientific facts, that are as useful and necessary both to the art of design and to the mechanics of wood construction.

280. **Botanical Division of Trees.** Botanically speaking, trees may be divided into three general groups:

1. The naked seeds, also known by the less accurate names of conifers or cone-bearing trees, evergreens, needle-leaved, and softwoods. Examples of this group are: pines, cedars, and redwoods.
2. The two-seed leaves, more commonly known as broad-leaved trees, deciduous trees which shed their leaves annually, and hardwoods. Examples of this group are: oak, mahogany, maple, and gum.
3. The one-seed leaf, such as the palms, yuccas, and bamboos.

It is in the first two groups of trees, the naked seeds and the broad-leaved trees, that we are chiefly interested, because these groups furnish all the lumber used for building construction, furniture, paper, and manufacture in general. The third group, the palms and bamboos, has little value for the woodworker, and is seldom used by him.

281. **Life Function of Trees.** A tree consists of three main parts, the roots, the trunk, and the crown. Water and minerals in solution are taken up by the roots and conducted through the trunk to the crown, where they are changed into food material in the thousands of leaves. The crown is, therefore, the most important part of a growing tree. The manufacture of food in the leaves takes place in the following manner: Water and minerals from the soil in solution are conducted from the roots to the cells in the leaves. Carbonic acid gas (CO_2), taken from the air, is also breathed in by these cells. Under the influence of sunlight, which penetrates the green (chlorophyll) cells of the leaves, these inorganic substances enter into various chemical combinations and form an organic substance, sugar ($C_6H_{12}O_6$). Part of this sugar is turned into starch and stored for future use. When it is needed, the starch is again changed into sugar, which is the food of the tree. Sugar, in combination with other chemical compounds, produces cellu-

lose, the principal material of which the cell walls are made, and fatty oils which are contained in seeds and bulbs.

One thousand square feet of leaf surface will manufacture 1 lb. of starch in 5 hours.

During these digestive processes, oxygen (O) and water vapor are given off to the air. This is an important factor in cooling off the atmosphere on warm summer days. The oxygen is used by man and beast for breathing, and is consumed by all kinds of fuels in burning. The water vapor is placed in circulation by the air currents, and moved from place to place.

The daily evaporation of water vapor from trees planted on the banks of lakes or rivers is extremely large. An oak tree, for example, may give off as much as 2,000 lb. or 240 gal. of water vapor in 24 hours.

282. Man's Dependence on Plants. Green plants use, therefore, only inorganic materials for their food supply and energy. Man and animals, on the other hand, use organic materials and are dependent on plants for oxygen for breathing; for different kinds of food containing vitamines, sugars, starches, fats, and proteins; for clothing material such as cotton and linen; for lumber, paper, medicines, rubber, alcohol, turpentine, and numerous other products. Moreover, because animals feed on plants, man also obtains such materials as milk, eggs, meat, wool, silk, leather, etc., indirectly from plants.

283. Conservation of Lumber. Since plants, and in particular, trees are so vital to the life of man, it is of the greatest importance to conserve our forests and protect the trees against dangers from fires, decay, destructive and wasteful methods of lumbering, etc. Enormous quantities of lumber have been wasted through neglect and carelessness in the past, but much is being done at present to eliminate such waste and conserve the supply of lumber.

Deforested areas are being replanted, more careful methods of lumbering are being enforced, less lumber is being wasted by modern methods of sawing, and new methods of preservation and utilization of lumber are being perfected through research. The government has established such a research laboratory in the Forest Products Laboratory at Madison, Wis.

In order to understand and appreciate the problems involved in the intelligent and economical usage of wood, it is necessary to give some attention to the study of the structure of wood and to the cutting, seasoning, and use of the commercial product—lumber.

STRUCTURE OF WOOD

Of the three classes of trees we have mentioned, the conifers and broad-leaved trees are quite similar in structure, while the palms are entirely different. Only the first two classes will be considered in this discussion.

284. Cell Formation. Examining a cross section of wood under a microscope (Fig. 352), the wood will be found to consist of innumerable small cells growing in a vertical direction. Some of these cells are small and some large. The larger cells have thin walls, and grow rapidly during the spring. The smaller cells have thick walls, and grow less rapidly during the summer.

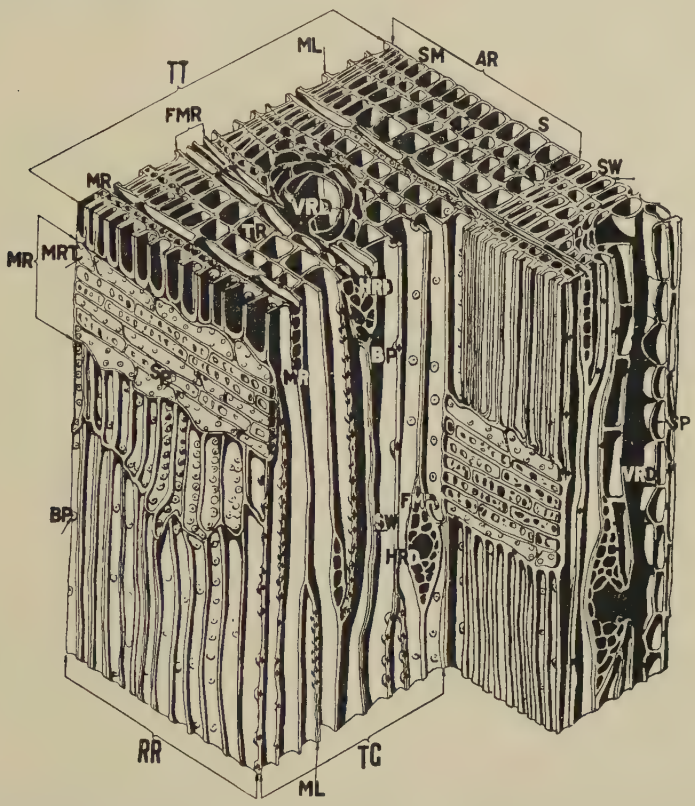


Fig. 352. Microscopic section of a soft wood. TR, Cells carrying water; S, spring wood; SM, summer wood; AR, one annual ring; MR, medullary rays

285. Annual Rings. Looking at a cross section of a tree (Fig. 353) with the naked eye only, the small thick-walled cells, or summer wood, appear as thin concentric circles, and the thin-walled cells, or spring wood, as wider circles or rings alternating with the first ones. One year's growth, or one "annual ring," as it is called, consists of one narrow and one adjoining wide ring. In this way, by counting the rings, anyone is able to tell the age of a tree. Sometimes a hand lens is required to see the rings.

286. Heartwood and Sapwood. The inner core of a tree trunk is

called the "heartwood" and the outside part the "sapwood." The center of the heartwood is a white, soft substance called the "pith." The sapwood is usually of a lighter color than the heartwood. The sapwood conducts the water, called "sap," from the roots to the crown. As the tree grows older, and new outside layers of wood are added, the inside part of the sapwood gradually turns into heartwood. The cells then clog up and no longer serve to conduct the sap to the leaves. Through infiltration of chemical substances into the cells, the heartwood turns a darker color.

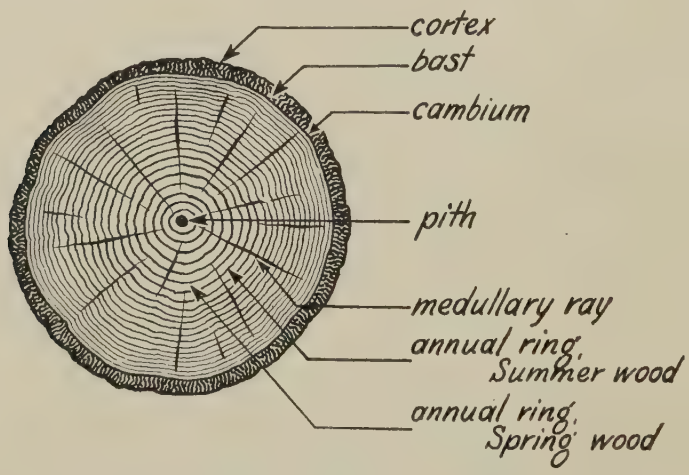


Fig. 353. Cross section of a tree

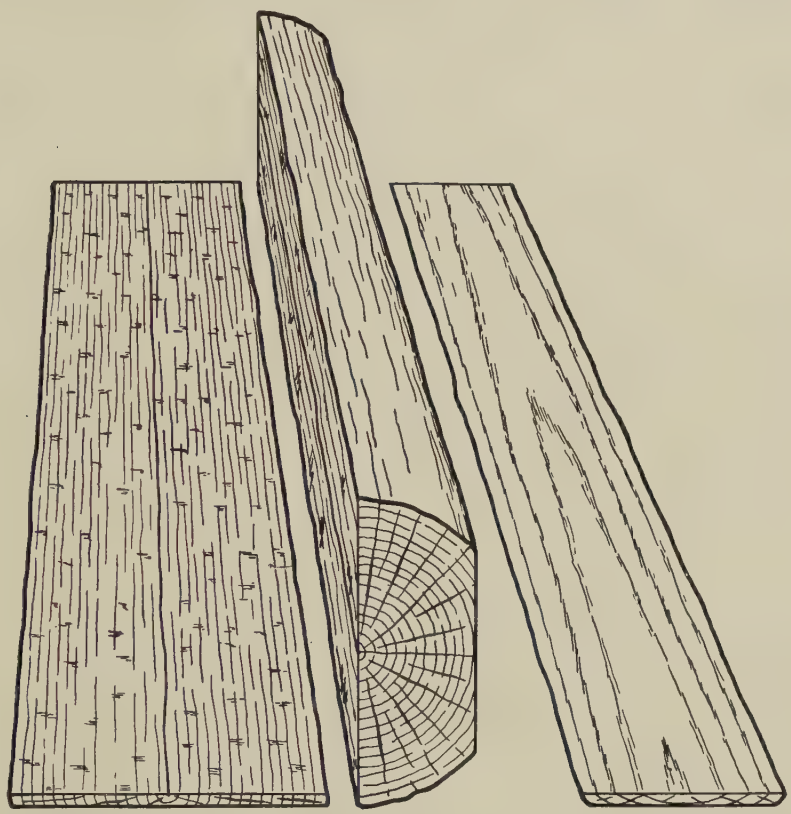
287. **Cambium.** Between the sapwood and the bark is a greenish, slippery, slimy layer called the "cambium." The cell formation takes place in the cambium. When a cambium cell grows to maturity, it divides into two parts, one of which always remains cambium. The other part forms either wood or bark; most frequently wood.

288. **Bark.** Outside the cambium lies the bark. It consists of a thick outer part, called the "cortex," and a thin inner part, called the "bast." Both the cortex and the bast are important commercial products. The cortex furnishes such materials as cork, tannic acid, medicines, etc. Bast is used in the weaving of mats, cloth, rope, etc.

289. **Medullary Rays.** On some woods, notably oak, some bright lines crossing the annual rings will be seen to radiate from the center. These lines, when seen under the microscope, will be found to consist of a horizontal series of cells. The function of these cells, which are called "medullary rays," is to store and distribute food material horizontally. These cells appear in all species of wood, but are not visible to the naked eye in all instances.

When a tree trunk is cut lengthwise through the center, a section

called a "radial section" is formed, as shown in Figure 354. In this section the annual rings appear as a series of parallel lines, and if the medullary rays are prominent, they appear in various patterns and lines crossing the annual rings. When a tree trunk is cut lengthwise,



A B

Fig. 354. Boards cut from log. A, Quarter-sawed or radial section; B, plain-sawed or tangential section

but not through its center, a section called a "tangential section" is formed, because all lengthwise cuts from a solid trunk, that do not go through the center of the trunk, are tangent to some annual ring.

In the tangential section, Figure 354, the annual rings, which are the grain of the wood, appear in pleasing patterns, especially in the center of the section. Near the edges, the annual rings are more straight, having the appearance of a radial section.

290. Porous Woods. The chief difference between the structure of conifers and broad-leaved trees is that the first are simpler in struc-

ture and nonporous, and the second more complex in structure and porous.

The cells in nonporous woods are so small that they cannot be seen without the aid of a magnifying glass. The pores in porous woods, on the other hand, are large sap-conducting vessels consisting of several

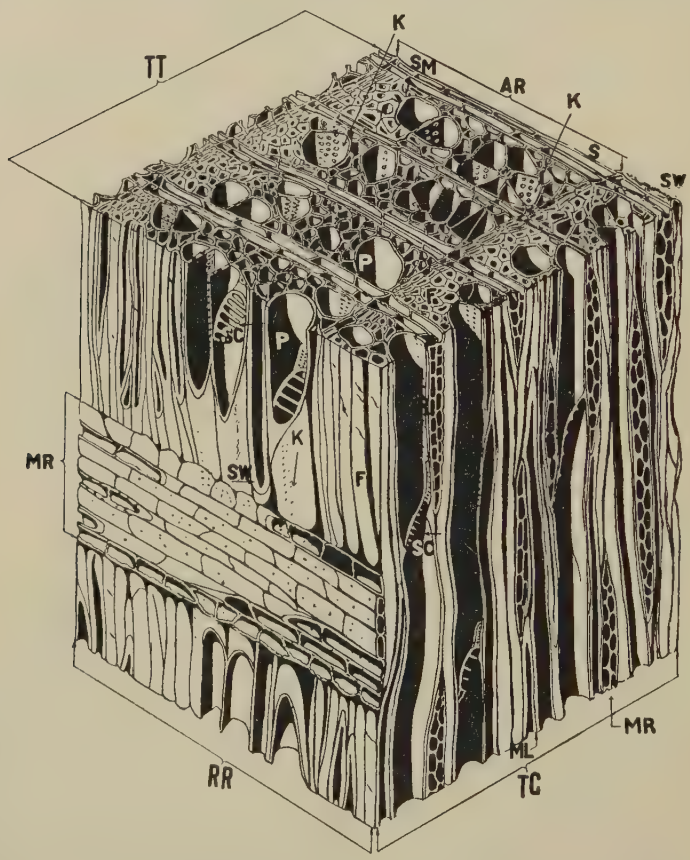


Fig. 355. Microscopic section of a hard wood. P, Pores; S, spring wood; SM, summer wood; AR, One annual ring; MR, medullary rays; TT, cross section; RR, radial section; TG, tangential section.

cells joined together. These pores usually can be distinguished with the naked eye. (Fig. 355.) In some woods, as in oak, chestnut, and ash, the pores appear mostly in the spring wood; in others, as in mahogany, beech, or maple, they seem to be distributed through both the spring and summer wood. The first of these groups is called "ring-porous wood" and the second "diffused-porous wood."

Paste wood filler is used only on porous woods, which in the lumber trade are called "hardwoods." (Art. 267.)

291. Weight of Wood. From the foregoing, it should be clear that wood is not a solid mass, but a combination of very complex cell structures. Wood is generally thought to be lighter than water, because, under normal conditions, it floats on water. That this is due to air contained in the cells can be demonstrated by a very simple experiment.

Fill three glasses with water. Drop a little sawdust in the first, some very thin shavings in the second, and a small block of wood in the third. The sawdust sinks almost immediately, the thin shavings sink within a few minutes, but the block continues to float.

The explanation is simple. Sawdust consists of such small particles of wood, that the cells are partly destroyed and open. Therefore, they fill up with water immediately. The cells of the thin shavings also fill up readily, because they are practically all on the surfaces. But the interior cells of the block cannot be reached, and, therefore, it continues to float. If a freshly cut log is placed in water, it will sink in a comparatively short time, because so many of its cells are filled with sap, a condition known as "water logging." A seasoned log, on the other hand, will float for months or years, before enough of its cells can be filled to make it sink.

The wood substance found in both heavy and light woods is heavier than water. Different authorities state that it is from 1.5 to 1.6 times as heavy as water. Heavy woods are more compact and contain more wood substance per cubic inch than do light woods. Some tropical woods are so dense that they do not float on water, even after seasoning.

292. Reproduction of Trees. Trees reproduce themselves by seeds and by sprouting. Some seeds are heavy, as those of the chestnut, oak, and hickory, and, therefore, fall close to the parent tree. Other seeds are light and wing-shaped, as those of the birch, pine, maple, and poplar. These may be carried long distances from the parent tree by the wind.

Nearly all the broad-leaved trees possess the power to reproduce themselves by growing new shoots from old roots, known as "sprouting." With one exception, that of the California redwood, the conifers lack the power to reproduce themselves by sprouting.

The knowledge of the method of reproduction of the various species is used by the forester in providing for new growth. One method, when felling trees, is to leave some old ones in a circle and clear the open space in the middle. The seeds from the old trees will then sow themselves in the cleared space, and a new crop will grow up there. Another method is to clear long, narrow spaces. The trees on the sides will then furnish seeds in the cleared spaces.

Reproduction by sprouts is used in forestry by dividing a piece of forest land into a number of equal parts and cutting one part at certain intervals. When the last section has been cut, the sprouts from the section first cut should have grown to maturity.

293. Logging Operations. The traditional methods of logging and the life in lumber camps are generally so well understood and described in books of fiction and motion pictures that little attention need be given to this subject. Trees are felled in summer as well as in winter without effect on their properties if the logs are properly cared for after cutting.

Fig. 356. Loading logs on cars in the woods

Before starting the actual logging operations on a tract of forest land, roads are built through the forest, and wooden buildings, known as the "camp," for housing the lumber crew, machinery, tools, supplies, etc., are constructed. Trees to be felled on government tracts are first marked, but with a few exceptions this is not done on privately owned tracts.

The actual felling of a tree is done as follows: Two men, the sawyers, chop a deep V-shaped cut, with axes, on the side of the tree toward which it is to fall. They then saw through the tree trunk from the opposite side, using a crosscut saw with a long flexible blade and two removable handles. (See end of log, Fig. 360.) After the saw enters the trunk, iron wedges are driven in behind the blade to prevent the weight of the tree from "pinching" it. As the sawing progresses, more wedges are driven until finally the tree falls.

The branches are now cut off close to the trunk, after which the trunk is cut into logs of standard commercial lengths. These logs are dragged out to the sides of the road, where they are piled, measured, and stamped on both ends with the owner's name. They are then

loaded on sleds or railroad cars and transported to the sawmill by rail. Formerly, logging operations were done entirely by hand methods, and horses or mules were used as draft animals. In recent years, power saws, derricks, tractors, and other modern machinery have come more and more into use. (Fig. 356.)

294. **Sawing the Logs.** At the sawmill, in order to prevent checking and decay, the logs are generally kept in a pond until wanted for

Fig. 357. Logs taken from pond into sawmill on jack ladder

sawing. From the pond, they are brought into the mill by means of an endless chain, called the "jack ladder," which grips them with steel prongs. (Fig. 357.)

The type of saw most commonly used in the modern sawmill is a very large band saw, with blades 50 ft. in length and 12 in. or more in width. These saws are run at speeds up to 10,000 ft. per minute, and usually have teeth cut on both edges. (Fig. 358.) This enables the sawyer to cut boards or planks from a log both on the forward and backward movements of the carriage, which runs on rails and to which the log is clamped. (Figs. 359 and 360.) Besides these big band saws, the sawmill is equipped with many other machines and appliances for sawing and handling the logs. This machinery, however, is so specialized and complicated that a description would be neither profitable nor of general interest to the woodworker.

295. Plain- and Quarter-Sawing. A log is sawed in one of two ways, either "plain-sawed," or "quarter-sawed." Plain-sawing means the sawing up of the entire log in a series of parallel cuts. (Fig. 354.)

Fig. 358. Interior of filing room. Double-cutting band saws, 16 in. wide

Fig. 359. Sawing logs into boards

In other words, all the boards sawed in this way, except the middle ones, will be tangential sections of the log, because they are tangent to the annual rings.

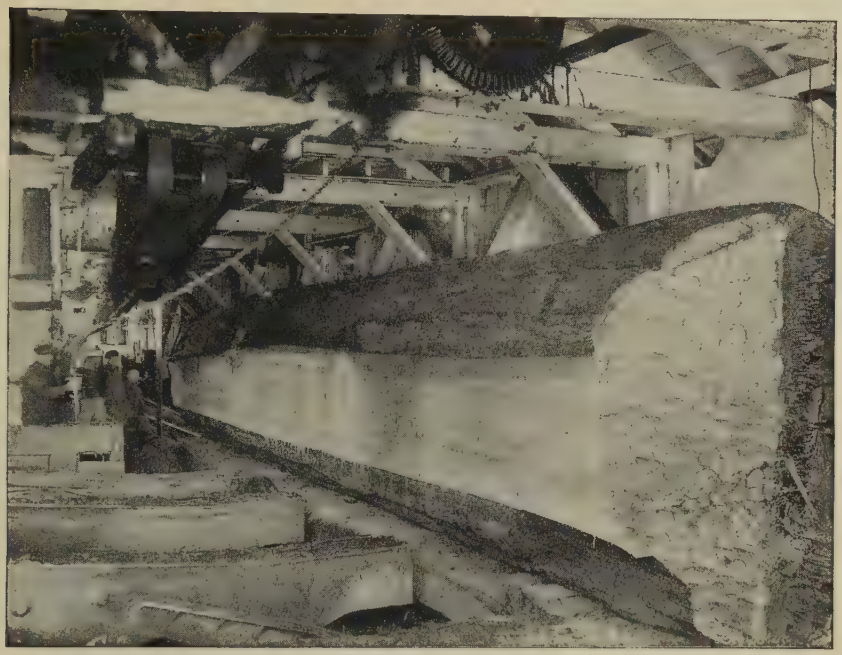


Fig. 360. Douglas-fir log on saw carriage

When a log is quarter-sawed, its position on the carriage is changed several times (Fig. 361), so that the saw cuts are always made at right angles, or nearly so, to the annual rings. Quarter-sawed boards are, therefore, radial sections of the log.

Quarter-sawed boards are more expensive than plain-sawed boards, because the waste by this method of sawing is greater. They have an advantage over common-sawed boards, however, in that they warp and shrink less. In some woods having prominent medullary rays, such as oak, quarter-sawed boards are also more beautiful in appearance. The best pine flooring is quarter-sawed, because on plain-sawed boards the annual rings often come loose, or "shell out."

296. Seasoning of Wood. After the logs have been sawed, the boards, planks, or timbers are seasoned or dried. This is one of the most important and difficult processes in the manufacture of lumber, because the excellence of the finished product, be it a large building or a small piece of furniture, is directly dependent upon the skill and care given to the drying of the lumber entering into its construction.

Briefly, the purpose of seasoning is to remove the moisture from the innumerable cells of which the wood is composed. Each of these cells may be thought of as a small vessel with porous sides and bottom. Water or "sap" occurs in wood in two forms, "free" and "imbibed."

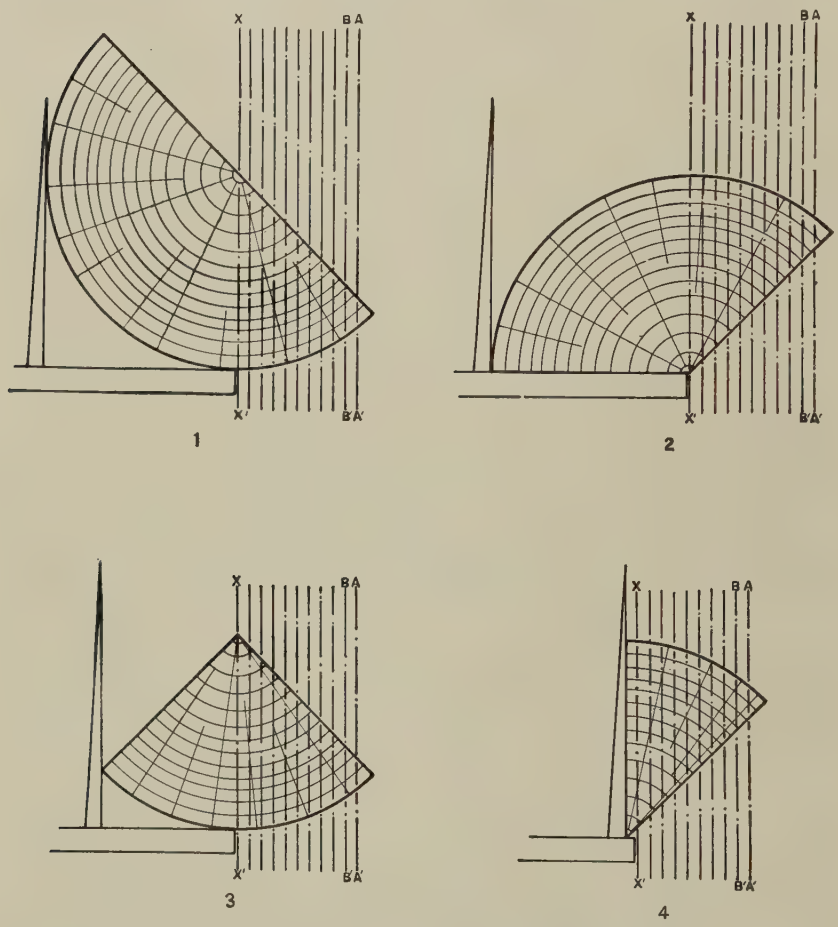


Fig. 361. Common method of quarter-sawing lumber

Free water is the amount each little vessel or cell contains, and imbibed water is the part absorbed by the porous walls of the cell. Most living trees contain free water in the cells of both sapwood and heartwood, but more in the former.

When the wood dries, the free water first evaporates from the cells. This is called the "fiber-saturation point." Drying beyond this point

extracts the imbibed water from the cell walls and causes them to shrink. This loss of moisture makes the wood harder, stronger, stiffer, and lighter in weight. The drying or seasoning of lumber is usually done in one of two ways or in a combination of the two.

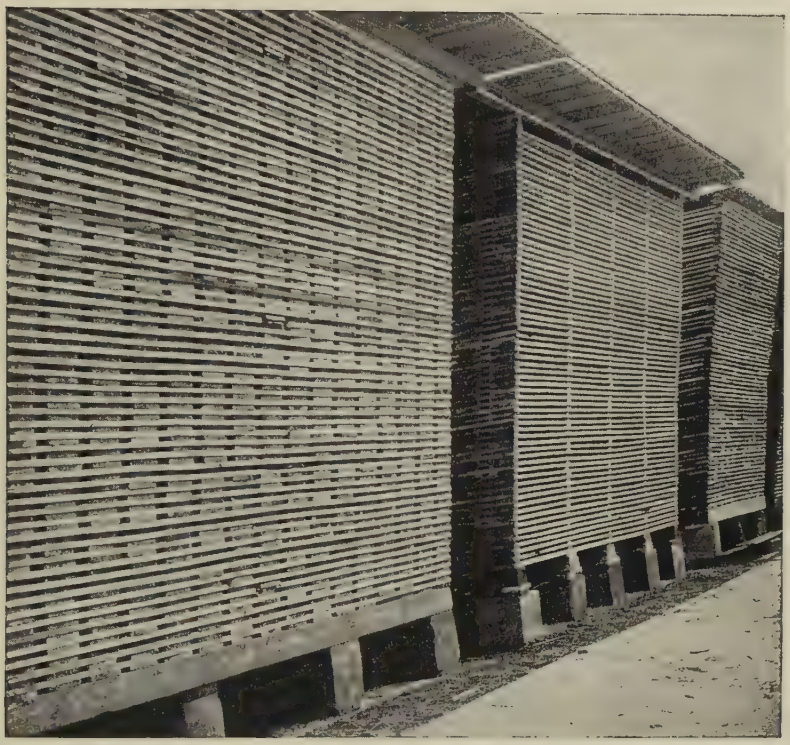


Fig. 362. Lumber piled for air drying

297. **Air seasoning** is the oldest method. It consists of piling the boards or planks carefully in the open air. Small sticks, ⅞ by 2 in., planed on both sides, are placed crosswise between each layer of boards, and a small open space is left between their edges. Air can, therefore, circulate freely around each board. The boards are also protected against sun, dampness from the ground, and rain. (Fig. 362.)

This method is good, but slow. Seasoning may be accomplished scientifically. Many manufacturers are now using the kiln-drying method, which is more rapid, and permits drying to a lower moisture content.

298. **Kiln Seasoning.** A kiln is an oven in which lumber is dried or seasoned. Every important sawmill and woodworking factory is

equipped with one or more of these kilns. (Figs. 363 and 364.) The purpose of kiln drying, which is a very complex process, is to produce a rapid evaporation of the moisture contained in "green wood." This evaporation depends upon three factors: heat, humidity, and circulation. The control and application of these factors in the correct proportion is the main problem in kiln operation, and spells success or failure for the finished product.

299. **Moisture Content.** The usual method followed in kiln drying is to determine the moisture content of the boards to be dried just before entering the kiln and at various stages of the drying process. This is done as follows: A cross section of a board ¾ in. long is cut

Fig. 363. Lumber kilns

at least 2 ft. from the end of the board. This is necessary because the wood dries faster at the ends. A section cut from the end of a board would, therefore, not be a true sample of the moisture content in the middle of the board. This sample is carefully weighed on a sensitive scale, after which it is baked in a small electric oven until it no longer loses weight. The difference between the two weights is then divided by the oven-dry weight, and reduced to per cent by multiplying by 100. For example, if the original weight is 195 units, and weight after drying is 150 units, the difference in weight is 45 units. This 45, divided by 150 and multiplied by 100, gives a result of 30 per cent. During the drying process, the moisture content is calculated in a similar manner by cutting and weighing samples from the kiln.

The final moisture content varies somewhat with the purpose for which the lumber is to be used. For furniture, it should be from 5 to 7 per cent; for outdoor material about 12 per cent.

Thoroughly air-seasoned wood averages from 12 to 18 per cent in moisture content, depending on local climatic conditions. High-grade

lumber is usually air-dried for some months, before the process is completed in the kiln. The moisture content of lumber varies with changes in the relative humidity of the surrounding atmosphere.

Air-dried lumber also will absorb moisture from air until a state of equilibrium is reached. Kiln-dried lumber will again absorb some moisture from the air, and air-dried lumber will lose more moisture if stored under heated conditions. Paint or varnish finishes do not prevent changes in moisture content, but they considerably delay the rate at which the changes take place.

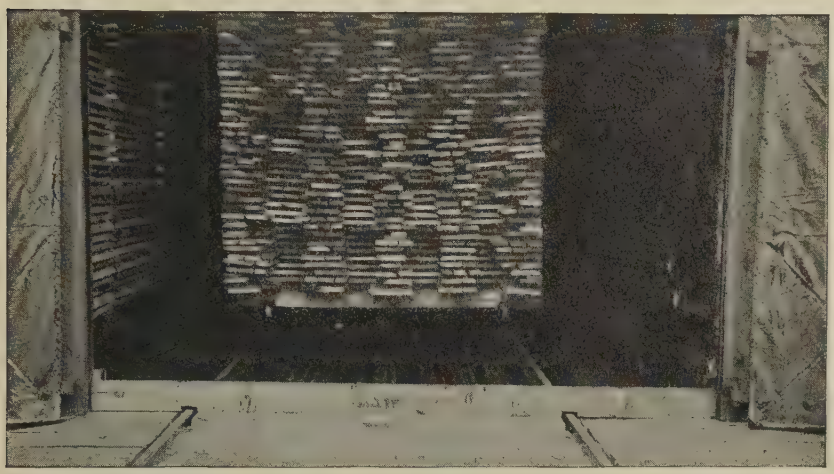


Fig. 364. Charge of lumber in kiln

300. **Types of Kilns.** Kilns are of two general types, known as the compartment or "box" kiln and the progressive or "continuous" kiln. In the first type, the material to be dried, called a "charge," remains in the same place during the drying period. In the second type, the charge enters at one end, and is moved through different compartments of varying heat and moisture content, until it leaves the other end completely dried.

The time consumed in kiln drying varies with the kind and thickness of the lumber and its moisture content before drying. A 1-in. board dries four times as fast as a 4-in. plank, but twenty times as fast as 10-in. timber. The drying time of 1-in. boards varies from 14 days to 4 or 5 weeks.

301. **Shrinkage of Wood.** When the fiber-saturation point has been reached in the drying process, the wood begins to shrink. As explained above, this means that all the free water has evaporated, and that the imbibed water in the cell walls is beginning to evaporate. This causes a reduction in the thickness of the cell walls, and the thicker the

walls are, the more they shrink. Summer wood, therefore, shrinks more than spring wood, and heavy wood more than light wood.

Wood shrinks in three directions: (1) tangentially, or along the circumference; (2) radially, or along the diameter, and (3) lengthwise. The lengthwise shrinkage is so small that ordinarily it may be disregarded. The tangential shrinkage, on the other hand, is from one and one half to three times greater than the radial shrinkage. A glance at

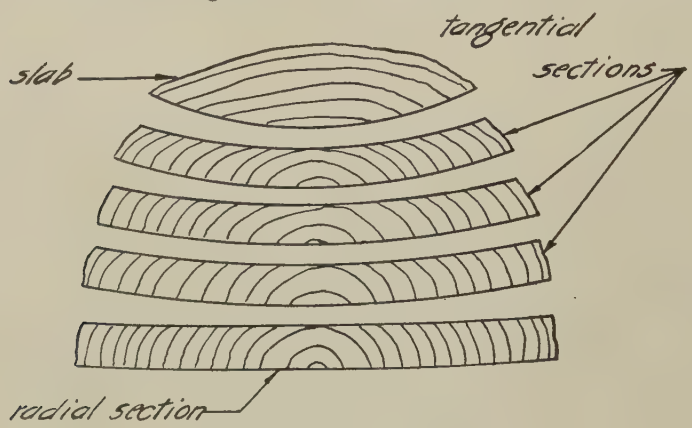


Fig. 365. Effect of shrinkage

Figure 365 will make this matter clearer. The board sawed through the center is practically straight, because it is sawed at right angles to the annual rings, or quarter-sawed. These annual rings are short and, therefore, cannot pull in a circular direction. On the other boards, however, the annual rings are longer on one side than on the other. The pull is, therefore, greater on one side, the outside, than on the other, or heart side, and the boards bend as shown, away from the heart of the timber.

302. **Drying Defects.** It follows that the shrinkage of millions of little cells causes tremendous stresses in lumber which is drying. If not properly relieved, by adding moisture, the wood will split or crack in various ways. Some of the most common drying defects are "honeycombing" and "casehardening." (Fig. 366.)

"Honeycombing" means a series of checks or cracks either on the surface or in the center of the board. "Casehardening" means the drying of the outside layers of cells before the inside ones have had an opportunity to do so. The surface of a board, however, cannot shrink properly until after the center has shrunk, thus causing this surface to become set when expanded. Then, when the inside layers of cells become dry and are ready to shrink the wood becomes stressed.

The lumber dealer divides all species of wood into two general classes, softwoods and hardwoods.

MANUFACTURED LUMBER

Softwoods, or conifers, are used mainly in building construction, while hardwoods, or broad-leaved trees, are used mainly in furniture construction.

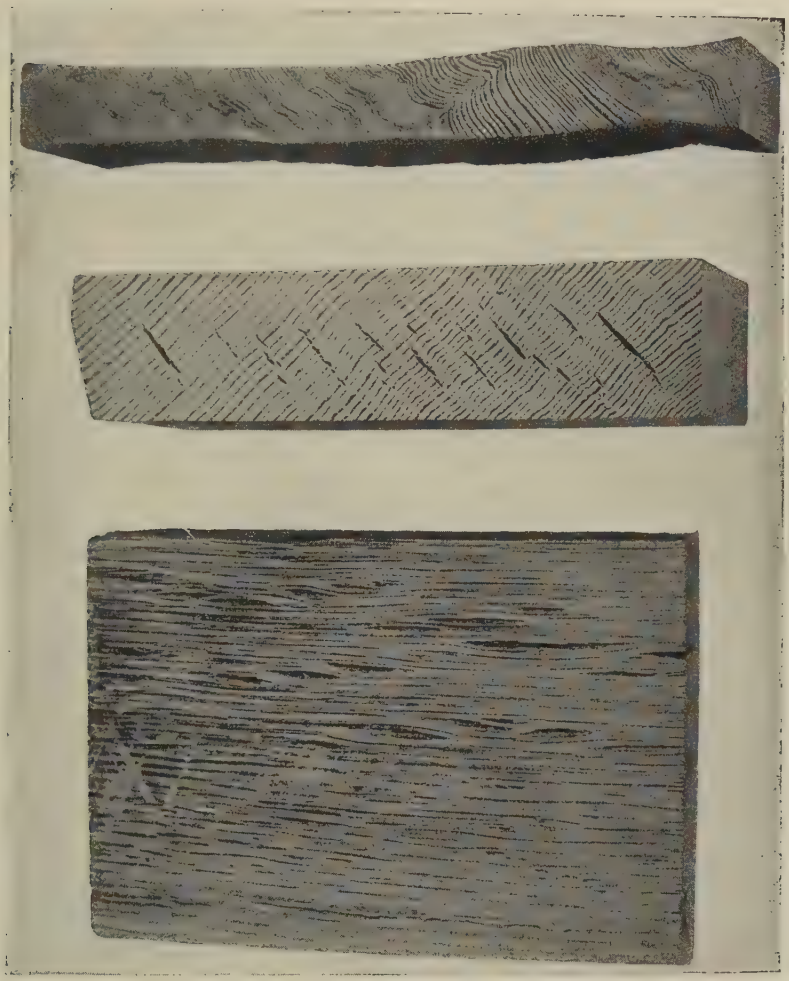


Fig. 366. Drying defects. Upper piece shows collapse; two lower pieces show honeycombing

303. Standard Lengths and Thicknesses of Lumber. Softwoods are generally cut to even lengths as 10, 12, 14, 16, and 18 ft., while hardwoods are furnished in odd lengths and "shorts." Boards are from ½ to 1½ in. in thickness, planks from 1½ to 4 in., and timbers are more than 4 in. thick.

304. Allowance for Planing. The above thicknesses refer to rough lumber only; i.e., lumber as it comes from the saw. For material less than 1½ in. in thickness, 1/16 in. is allowed for each planed surface. For material more than 1½ in. in thickness, ⅛ in. is usually allowed for each planed or "dressed" surface. A 1-in. board, dressed on both sides, is therefore only ⅞ in. thick, and a 2-in. plank, dressed on both sides, is only 1¾ in. thick.

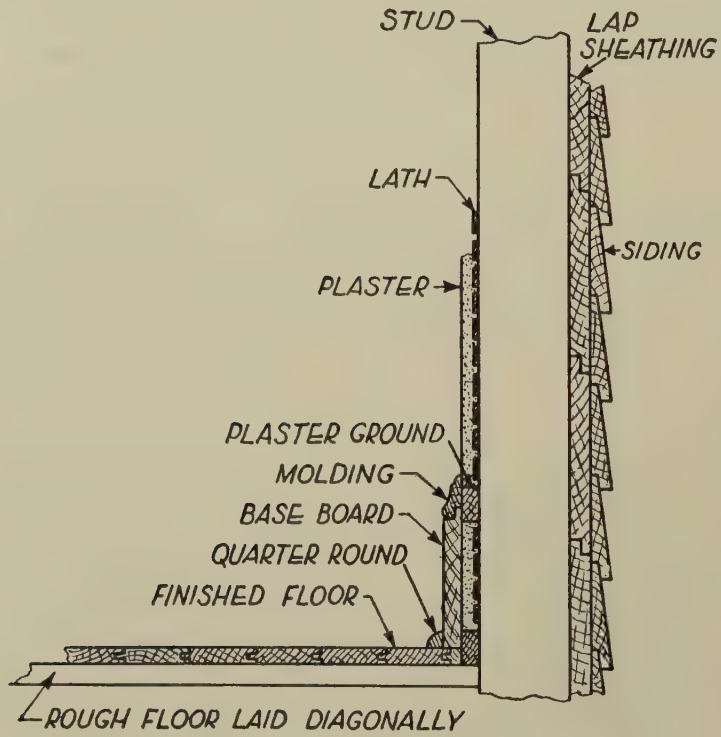


Fig. 367. Types of manufactured lumber

305. Board Measure. This loss in thickness, however, is not counted when the boards are sold. The purchaser of dressed boards pays for the shavings removed by the planer. Lumber is sold by the board foot. Each board foot is the equivalent of a piece of lumber measuring 1 in. in thickness, 1 ft. in width, and 1 ft. in length. To calculate board feet, multiply the thickness and the width of the board in inches by its length in feet, and divide the product by 12. The easiest method of doing board measure is to use cancellation. The dimensions of lumber are always written in this order: thickness, width, length. On the cheaper grades of lumber, ½ in. is disregarded. A board less than 1 in. thick is counted as 1 in. A board thicker than

1 in. is figured to the nearest larger quarter inch in thickness. Thus, $1\frac{1}{8}$ in. is calculated as $1\frac{1}{4}$ in., $1\frac{3}{8}$ in. as $1\frac{1}{2}$ in., etc.

Examples: Find the number of board feet in the following:

1 piece $\frac{7}{8}'' \times 3''$ $\times 10'\text{-}0'' = 1 \times \frac{3}{12} \times 10 = 2.5$ board feet.

1 piece $\frac{3}{4}'' \times 6''$ $\times 17\frac{1}{2}'' = 1 \times \frac{6}{12} \times \frac{18}{12} = .75$ board feet.

1 piece $1\frac{3}{4}'' \times 6\frac{1}{4}''$ $\times 12'\text{-}0'' = 2 \times \frac{6}{12} \times 12 = 12$ board feet.

2 pieces $1\frac{3}{8}'' \times 7\frac{1}{2}''$ $\times 10'\text{-}6'' = 2 \times \frac{3}{2} \times \frac{8}{12} \times \frac{21}{2} = 21$ board feet.

Fig. 368. Beaded and V-shaped sheathing

Types of Manufactured Lumber. Besides plain boards, planks, and timbers, lumber for the building and furniture trades is manufactured into matched, grooved, and beaded boards, shingles, laths, moldings, veneers, plywood, overlays, etc.

306. Matched, Grooved, and Beaded Boards. Some of the most common of these are as follows: *Lap sheathing* are wide boards, rabbeted or grooved on the edges, and used to cover the framework of

Fig. 369. Veneer slicer

wooden buildings. (Fig. 367.) *V-shaped and beaded sheathing* are narrower boards of a better grade used for partitions, wainscot, etc. (Fig. 368.) *Siding* consists of matched and shaped boards covering the sides of frame buildings and nailed to the sheathing. (Fig. 367.) *Flooring* is of two kinds, rough and finished. (Fig. 367.)

307. Moldings are made in a great variety of shapes and for dif-

ferent purposes as base moldings, picture moldings, cornice moldings, etc. (Fig. 367.)

308. **Veneers** are very thin sheets of wood, usually cut from rare woods. They are glued to more common woods, either for the sake of appearance, or durability of construction, or both.

Veneers are cut by three distinct methods: sawing, slicing, and rotary cutting. Sawed veneers are cut just as common-sawed boards are cut from a log. Special saws and carriages permitting of very fine adjustments are used for this purpose. Sawed veneers are thicker than sliced or rotary-cut veneers.

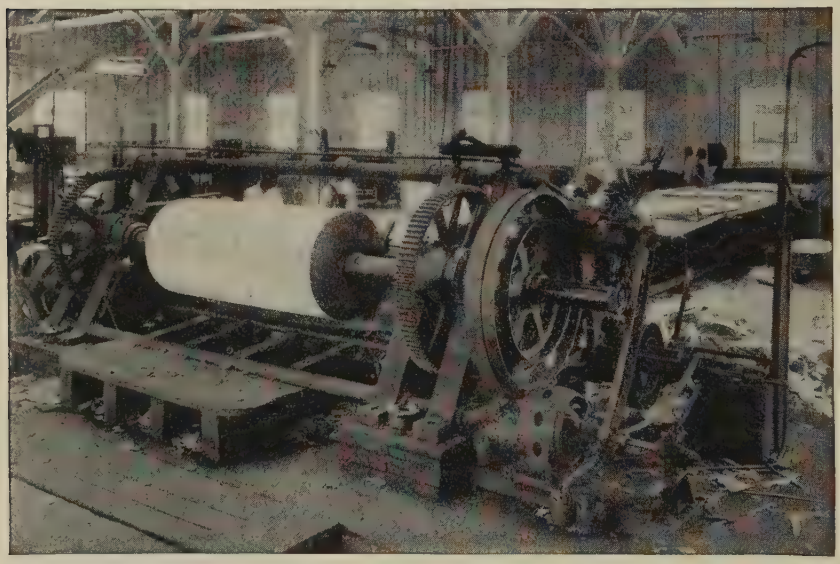


Fig. 370. Rotary veneer cutter

Sliced veneers are cut on a machine having a very large fixed knife, against which the log to be cut is pushed. Each time the log is pushed over the knife, a thin sheet from $\frac{1}{28}$ to $\frac{1}{20}$ in. in thickness, or thinner, is cut. (Fig. 369.) As many of the sheets cut from one log have practically identical patterns, beautiful effects are obtained by combining or matching such veneers. (Art. 248.)

Rotary-cut veneers are cut from a round log on a very large, specially constructed lathe. The log is turned between centers, while a long knife is pushed against it. The action of the knife may be likened to peeling. As the knife has a side movement toward the center, corresponding to the rate at which the log is revolved between centers, one continuous slice or peeling of uniform thickness is cut from the log. (Fig. 370.)

309. Plywood is a comparatively new product of the woodworking industry. As its name suggests, it usually consists of an odd number of layers or plies of wood glued together so that the grain of alternate pieces runs at right angles. Plywood is manufactured in different thicknesses, sizes, numbers of plies, and grades of lumber. Three-ply panels are ¼ or ⅜ in. thick, and of various widths and lengths. Panels consist simply of a core, usually of inferior or defective wood, to each side of which a sheet of veneer has been glued, the grain of the core being at right angles to the grain of the veneers.

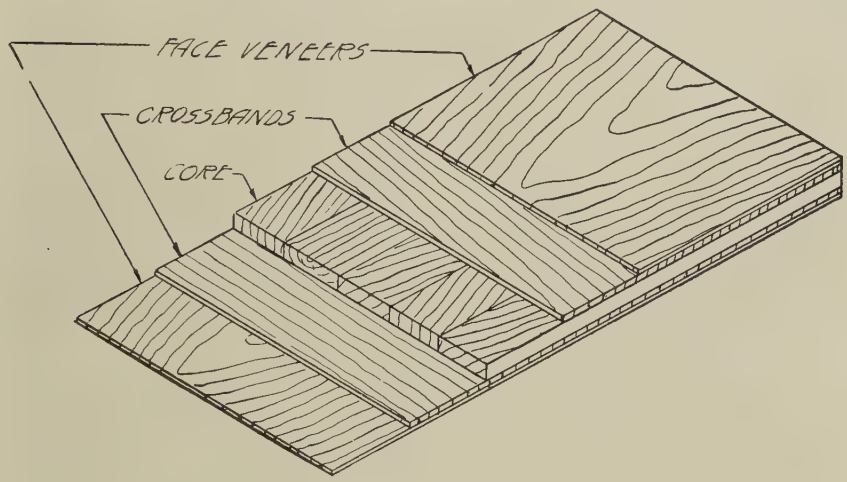


Fig. 371. Five-ply board

Five-ply panels consist of a core, to the face and back of which a sheet of common veneer is glued with the grain running at right angles to that of the core. (Fig. 371.) These sheets, next to the core, are called "crossbands." A sheet of thin veneer, usually of a higher grade, is then glued to each of the crossbands. These outside veneers are called the "faces." The grain of the face veneers runs at right angles to the crossbands, but in the same direction as the grain of the core.

310. Uses of Plywood. Tops, panels, doors, and drawer fronts of some of the very fine furniture produced at present are made of five-ply material to prevent warping and shrinking under different climatic conditions. Both the core and crossbands are frequently made of the same kind of lumber as the face veneers.

Plywood also is used for partitions, panels, bottoms of drawers, overlays, etc. The cheaper grades also are used extensively in packing-box construction, because they are thinner and stronger than the solid wood ordinarily used for boxes.

311. Manufactured boards are considered superior to plywood

boards, because in them the tendency to warp, shrink, or swell under different climatic conditions, has been completely eliminated. Manufactured boards are made as follows: A number of well-seasoned boards about 7/8 in. in thickness are glued together in a hydraulic press to form a thick block. This block is then ripped with the grain into sections about 3/4 in. thick for a 1-in. board. (Fig. 372.) The width of

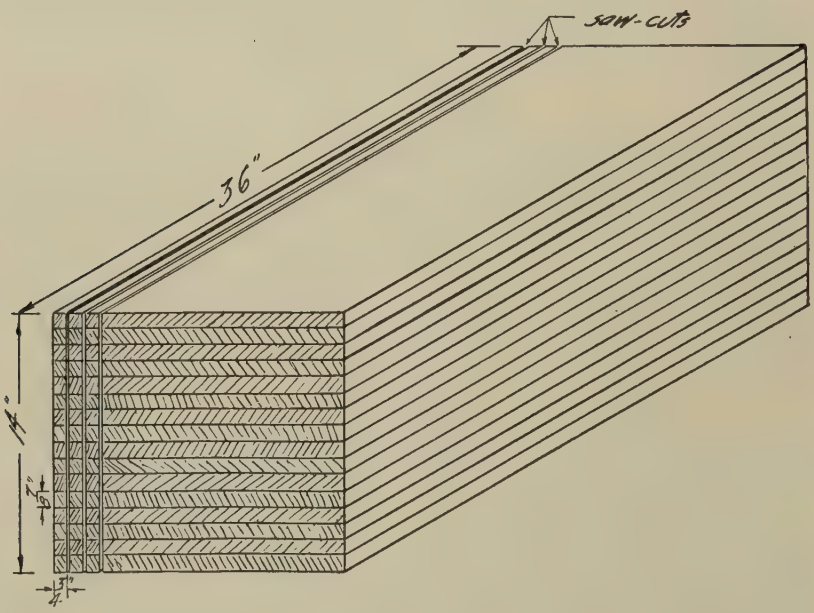


Fig. 372. Sections ripped from boards glued into solid block, these sections to form core of manufactured boards

the sections is equal to the thickness of the block. For example, if the block is built up of 16 layers, each 7/8 in. thick and 3 ft. long, the sections cut from it will be 14 in. wide (16 by 7/8 in. = 14 in.) and 3 ft. long. The 3/4-in. sides of these 3-ft. sections are glued together until the desired width is obtained. This glued section is the core of the

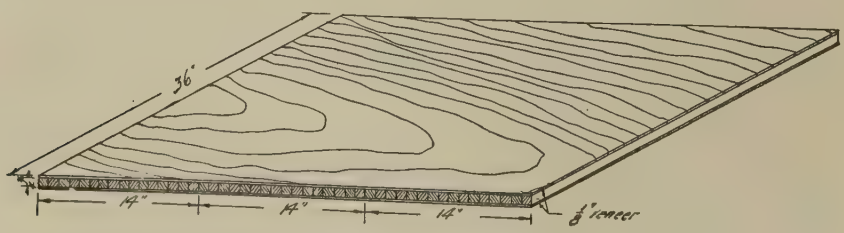


Fig. 373. Manufactured board. Core formed of three sections ripped from block, Figure 372

board. The core is then veneered on both sides with selected veneers about ⅛ in. thick. The grain of the veneers runs at right angles to the grain of the core. The whole board is then dried once more in the kiln, after which it is ready for use. (Fig. 373.)

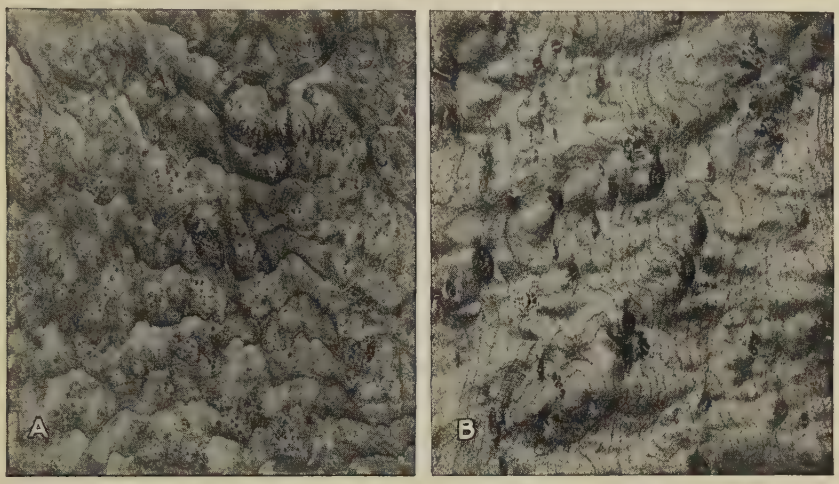


Fig. 374. Cabinet woods: A, cherry burl; B, bird's-eye maple

As most of the internal stresses have been eliminated, manufactured boards have little tendency to warp or split. These boards, which are made in various sizes and thicknesses, are used extensively in Europe

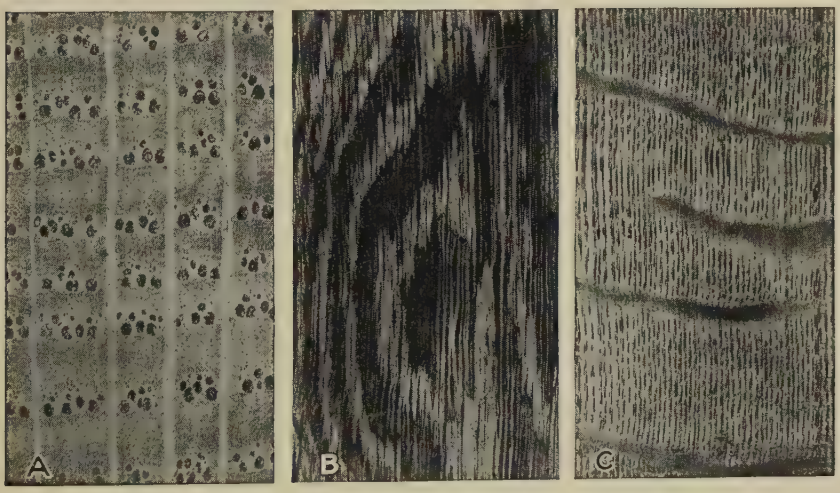


Fig. 375. Cabinet wood, white oak: A, end surface, magnified; B, plain-sawed; C, quarter-sawed surface

in all fine cabinet construction. Plain veneers can be laid at right angles to the outside grain of these boards, but fancy veneers, such as burl walnut and crotch mahogany, must be laid with a crossbanding of thin plain veneers. Veneers should always be applied to both sides of the manufactured board.

While the practice of manufacturing boards is quite common in Europe, it has not as yet been used to any extent in this country.

SELECTION AND USES OF LUMBER

312. **Lumber for cabinetwork and interior woodwork** should have certain qualities, as beauty of grain and color, freedom from warping and shrinking, hardness, and strength.

The grain, more than the color of wood, is the important consideration in furniture construction. Woods that might otherwise be suitable, as for example "Philippine mahogany," have no distinctive grain and are difficult to fill and polish. Cabinet woods having beautiful grain are mahogany, black-walnut burls, bird's-eye maple, cherry burls, quarter-sawed oak, birch, and red gum. (Figs. 374, 375, 376, and 377.)

Lumber that is free from undue warping and shrinkage is of most value to the woodworker. It certainly makes his work easier and better. Woods that warp and shrink but little are mahogany, black walnut, quarter-sawed oak, and chestnut. Woods that warp extensively are sycamore, elm, and beech, and to a less extent, birch, maple, and red gum.

Hardness also is an important consideration. A medium grade of hardness is the most desirable as soft woods are too easily nicked and damaged, and extremely hard woods are too difficult and costly to work. In this respect, mahogany and walnut also are the most desirable. Elm and cypress are examples of woods that are respectively too hard and too soft.

Strength does not play as important a part in cabinet woods as it does in structural timbers. Yet, chestnut is too brittle to make it a desirable cabinet wood.

To most people, price is probably the decisive factor in the selection of cabinet wood. Were it not for the high cost of mahogany and walnut, most woodworkers would, no doubt, prefer to use these woods to the exclusion of most of the others.

313. **Lumber for building purposes** should have qualities that differ somewhat from those that are desirable for cabinetwork. Important considerations are durability or resistance to decay and attacks by insects and worms, strength, and hardness.

For use in patternmaking, white pine is unsurpassed.

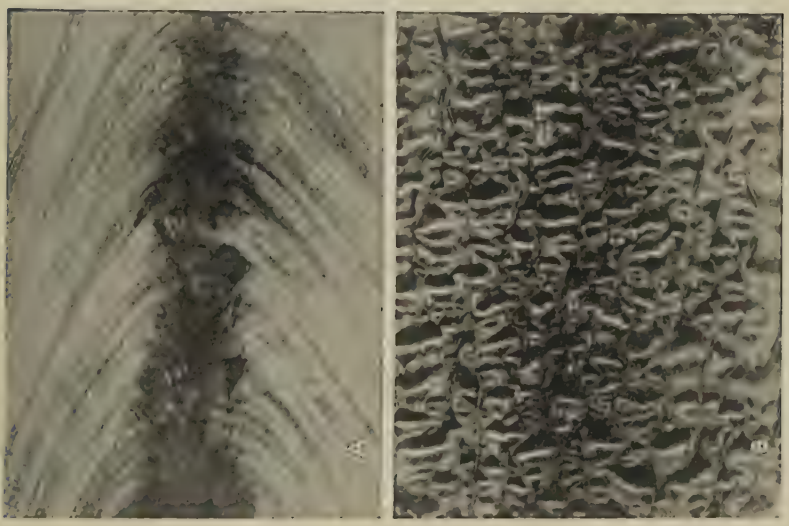


Fig. 376. Cabinet woods; A, crotch figure; B, blister figure in mahogany

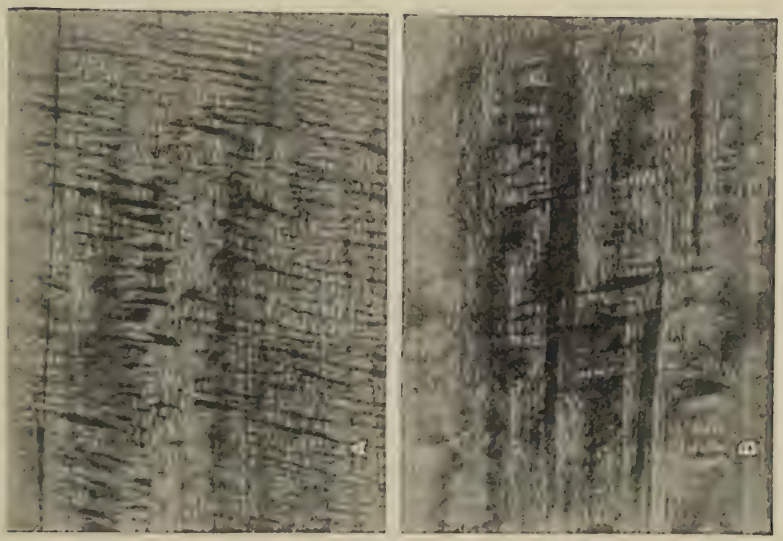


Fig. 377. Cabinet woods; A, fiddle-back figure; B, raindrop figure in mahogany

314. List of Principal Cabinet Woods. H, high; M, medium; L, low.

Species of Wood	Beauty of Figure	Warping and Shrinkage	Hardness	Uses in Cabinetwork
Ash	M	L	M to H	Refrigerators
Yellow birch	M	H	M	Medium-grade furniture
Sugar maple	L	M	M to H	Bedroom, porch, and kitchen furniture
Chestnut	M	L	L	Cores for veneers and inside parts
Quarter-sawed oak	H	L	M to H	Office furniture, veneers
Plain-sawed oak	M	M	M to H	Medium-grade office furniture
Red gum	M	M	L	Furniture in combination with mahogany
Black-walnut burls	H	L	M	High-grade veneers
Plain black walnut	M	L	M	High-grade furniture
Mahogany	H	L	M	High-grade furniture, veneers
Bird's-eye maple	H	M	M to H	Veneers, overlays

315. List of Principal Woods Used in Building Construction.

Species of Wood	Durability	Strength	Hardness	Uses in Building Construction
White pine	M	L	L	Door and window frames, inside work
Yellow pine	M	H	H	Framing timbers and floors
Hemlock	L	L	L	Bridging, cheap, rough framing
Cypress	H	M	L	Interior work, fascia, window sash
Cedar	H	L	L	Clothes' closets, shingles, posts
Spruce	L	L	L	Framing timbers and piling
Redwood	H	M	M	Railroad ties, telegraph poles, interior work

REVIEW QUESTIONS

1. How are trees classified botanically?
2. Which classes are of importance to the woodworking industries?
3. How does a tree take nourishment? Of what does that nourishment consist?
4. How does a tree digest its food and use it for growth?
5. Of what importance is the evaporation of water from the leaves of a tree?
6. Name ten materials obtained directly from plants and five materials obtained indirectly from plants.
7. What can be done to conserve our lumber supply?
8. How and in what part of the tree does the cell formation take place?
9. What is the difference between spring wood and summer wood? What causes the difference?
10. What are some of the commercial products obtained from the bark of trees?
11. What is the function of the medullary rays? In what kind of wood are they prominent?
12. Explain the difference between a cross section, a radial section, and a tangential section of a tree trunk.
13. How may nonporous, diffused-porous and ring-porous woods be distinguished? Give two examples of each.
14. Why does sawdust sink in water?
15. How do trees reproduce themselves?
16. When a tree is cut down, how is it made to fall in a given direction?
17. What is the most convenient way of transporting logs to a sawmill?

18. Why are logs kept floating in water until they are sawed?
19. What is the difference between plain- and quarter-sawing?
20. What are the advantages of quarter-sawed boards over common-sawed boards?
21. When is the "fiber-saturation point" reached in drying lumber?
22. What is a desirable percentage of moisture in lumber used for outside work? How is this calculated?
23. How may drying defects be prevented in a kiln?
24. In what direction does wood shrink the most? Why?
25. What is the usual allowance for planing?
26. How many board feet does the following bill of lumber contain?

4 pc. 1¾" x 1¾" x 30"	2 pc. ⅞" x 5 " x 2'-8"
2 pc. ⅞" x 5 " x 1'-6"	1 pc. ¾" x 20 " x 34"

27. How are veneers manufactured?
28. How are plywood panels constructed? For what are they used?
29. Name four qualities desirable in cabinet lumber.
30. Name four qualities desirable in lumber for building construction.

Since trees are so vital to man, it is of the greatest importance to conserve our forests and protect the trees against fires, decay, destructive and wasteful methods of lumbering, etc. (See p. 224.)

A mixed stand of hardwoods, Pisgah National Forest, North Carolina. (Courtesy U. S. Forest Service.)

CHAPTER XVIII

APPLIED PROJECTS

317. Preliminary Steps in Construction. Before attempting the actual construction of an object, it is of utmost importance that the different steps or operations involved in its construction should be carefully analyzed and arranged in the most systematic and convenient order. A bill of material should be written, and full-size details should be laid out from the drawings, either on paper or on a wood surface such as a plywood panel. This is called "setting out," and is done in all furniture factories and by all professional cabinetmakers. Too much emphasis cannot be placed on this phase of the work, because any small error, which may have been made in the scale drawing, is thereby corrected. Furthermore, this procedure clarifies the whole problem of construction, and helps the student to organize and arrange his work in an orderly and systematic manner.

The ability to read drawings correctly is, of course, essential for this preliminary work. For the benefit of those who have had little experience with drawings, a few hints on blue-print reading are given in the following.

318. The Making of Drawings and Blue Prints. The inventor or designer usually draws some rough sketches of the object he wishes to make. These are then worked out in detail with pencil and instruments. A piece of transparent cloth or paper, called tracing cloth or tracing paper, is fastened over the pencil drawing with thumb tacks. The pencil lines, which are visible through the transparent cloth or paper, are now traced on the latter with drawing ink. This ink drawing is called the "tracing." Any number of prints may be made from the tracing much in the same way that photographic prints are made from films or plates. The prints are made in sunlight or in artificial light on sensitized paper. This paper is then thoroughly rinsed in water and hung up to dry. The action of the sunlight causes these prints to turn a blue color when they are washed. The lines of the drawing, however, stand out white, because the light is not able to penetrate the black lines of the tracing. These prints are called "blue prints."

Blue prints are used by workmen in all parts of the world. They are not as easily soiled as a drawing made on white paper, and, moreover, they can always be replaced.

319. To Read Working Drawings. Persons who have not had a course in mechanical drawing, usually find it very difficult, if not im-

possible, to understand or interpret the kind of drawing used by the mechanic or artisan, because it does not represent an object as we are accustomed to seeing it. This type of drawing is called a "working drawing" because work is produced according to the exact information about size, shape, material, and methods of construction which it contains.

Working drawings differ radically from pictorial drawings, which represent an object as it appears to the eye and not as it really is. Perspective drawings, such as are used by the architect, etchings, paintings, and photographs are all forms of pictorial drawings. These, however, cannot be used by the workman, because they give no exact information about size, shape, material, or methods of construction.

In order to interpret a working drawing correctly, it is necessary to be able to form a mental picture; i.e., a pictorial vision, of its final shape. The experienced workman or draftsman does this automatically and without conscious effort. The best way of acquiring this ability is by comparing a working drawing with a pictorial drawing, so that the relation of one set of lines to the other is seen and understood.

320. To Read the Drawing of the Bookrack. For the sake of convenience in explaining the relationship between a working drawing and a pictorial drawing of the same object, a small perspective sketch has been drawn over the working drawing of the bookrack in Figure 378. The perspective sketch shows the bookrack as it will appear to the eye when it is finished; the working drawing gives all the necessary dimensions of the different parts, and shows how they are joined together.

Examining the pictorial drawing, we find that the bookrack consists of only three pieces: the bottom board and the two end pieces. The end piece is easily found to the right in the working drawing. We see that it is 6 in. wide and 6½ in. high, that its upper edge is curved, and that its lower edge is recessed 1 in. from each side to a depth of ⅛ in. The other dimensions and details shown in this view, called the "end view" or the "side view," do not concern us at present. But we must know how thick these end pieces are to be, and this dimension we find on the other view called the "front view" or the "elevation." In this view, only the edges of the three boards are shown; the shaded part on the pictorial drawing corresponds to them. At the left, we find the dimension we seek, because the end piece is shown to be ¾ in. thick. This dimension need not necessarily be repeated on the other end piece, because it follows that the two end pieces are exactly alike.

Having found the dimensions of the end pieces, each ¾ by 6 by 6½ in., we now look for the dimension of the bottom piece. On the front view, we notice that two dimensions are given, 16 and 16¾ in. We see that 16 in. is the distance given between the inside faces of the ends, and 16¾ in. is the distance from the center of one end to the center of the other.

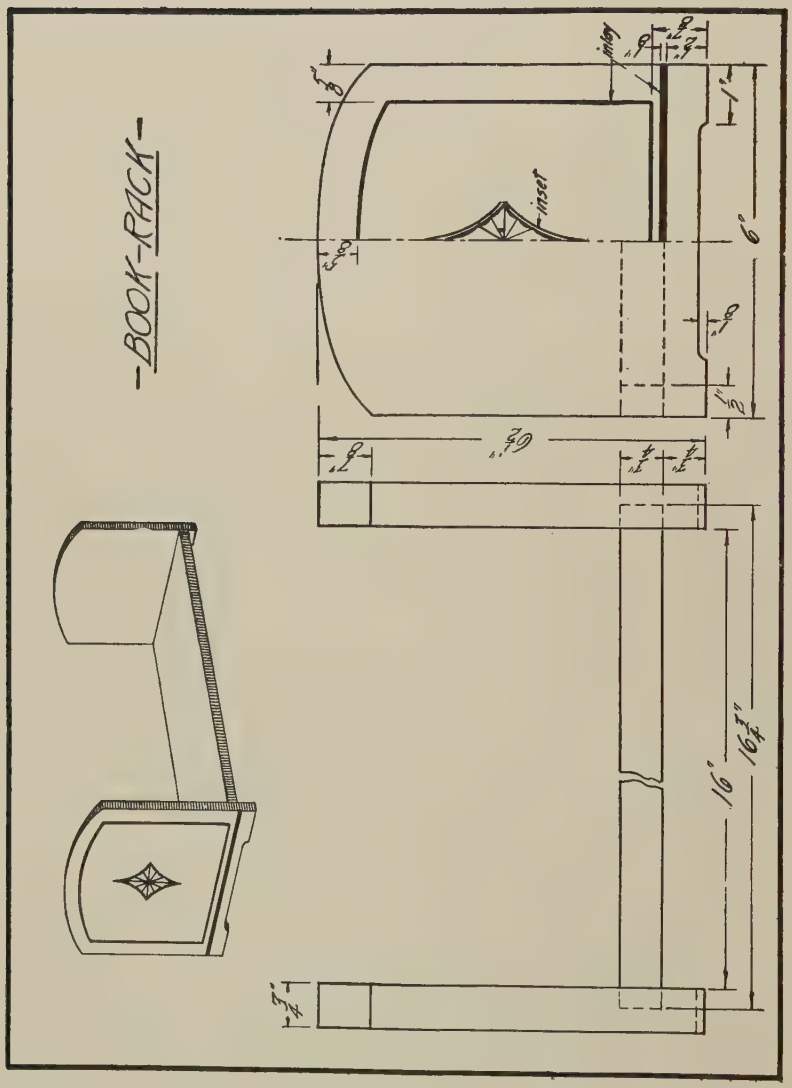


Fig. 378. Bookrack

The fact that the lines of the bottom board are broken near the center, indicates that the length shown on the drawing is not a true length. This is often done to economize on space. If it had not been done in this case, it would have been necessary to make the drawing smaller in order to get it on the paper. A smaller drawing is obviously not as clear as a larger one.

We also notice some dotted lines ¾ in. from the lower edges of both ends. Dotted lines inside a view are called "hidden lines," because they represent some part of the object that is hidden from view. In this case, it indicates that the bottom board is let into the end pieces to a depth of ⅜ in., and that the total length of the bottom board therefore is 16¾ in. The hidden lines also show us that the bottom board is ¾ in. thick, and that it is let into the end pieces ¾ in. from their lower edges. The other hidden lines near the lower edge of each end piece indicate the ⅛-in. recess cut into their lower edges. (See End View.)

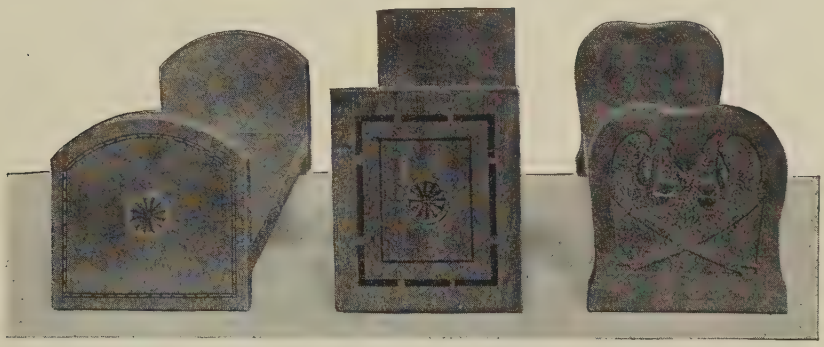


Fig. 379. Examples of bookracks

The full horizontal line, drawn across both end pieces ⅞ in. from their upper edges, indicates the corner formed where the curved upper edge and the straight side meet. Having found the thickness and the length of the bottom piece on the front view, we must now return to the end view to find its width. The end view is divided vertically into halves by a fine line consisting of alternate dots and dashes. Notice that the line extends both above and below the view. This line is called a "center line," and indicates that the parts of the object on each side of it are symmetrical or exactly alike in every respect. It was drawn in this case to show the structural details on one half of the view and the decorative details on the other half.

Looking at the left half of the end view, we see by the hidden lines that the bottom board extends all the way across the end pieces. It is, therefore, of the same width as these, which is 6 in. The vertical hidden line ½ in. from the edge shows that it is let into the end pieces to

within ½ in. of their edges. (See Gain Joint, Fig. 170.) If a groove or dado had been cut all the way across the end pieces, the total length of the bottom board, 16¾ in., would have been shown in the front view in full lines.

Turning now to the decorative details shown on the right half of the end view, we find that an inset is to be inlaid in the center and that border lines are to be inlaid around the edges. On a commercial drawing, these details would be made just as specific as any other information given on the drawing, but in this case they are merely offered as a suggestion for the decorative treatment of this project.

321. Bookrack. This type of bookrack (Fig. 379) is designed to stand on a table or writing desk. It will hold a few reference books such as those used by the student or professional man, or it may hold one's favorite volumes. The length of the bookrack should, of course, be adjusted to fit individual needs. The opportunities for originality in design and methods of decoration are practically without limit.

BILL OF MATERIAL

No. of Pieces	Description	Thickness In Inches	Width In Inches	Length In Inches
1	Bottom Board	¾	6	16¾
2	End Boards	¾	6	6½
1	Inset			
4 ft.	Line Inlay, 1/16 in. wide			
1 ft.	Line Inlay, ⅛ in. wide			

SUGGESTED ORDER OF TOOL OPERATIONS

1. Square the three pieces to dimensions. (Art. 138.)
2. Lay out, and make the gain joints. (Art. 148.)
3. Lay out the curve on top of the end pieces. Nail them together through the part that is to be cut away, and saw both at the same time.
4. Clamp them together in a bench vise, and smooth the curved surfaces with a file and sandpaper. It is easier to get a smooth surface and square edges if the two pieces are smoothed at the same time.
5. Inlay the lines as explained in Article 234. (Figs. 302 to 305.)
6. Inlay the inset according to directions given in Article 235.
7. When dry, smooth the inlaid surfaces with scrapers and sandpaper.
8. Glue the pieces together as explained in Article 191. (Fig. 235.)
9. Smooth off any irregularity on the edges of the boards when they are joined, and prepare the surface for staining. (Art. 261.)
10. Apply a coat of water stain after the surfaces have been washed with water and resanded. (Arts. 262 and 266.)

11. Apply a thin coat of white shellac (Art. 268), follow this by a coat of clear lacquer (Art. 269), and finish with a coat of liquid wax as explained in Article 271.

322. **To Read the Drawing of the Footstool.** Figure 380 shows the side of the footstool, its end, and most of its top. The working drawing (Fig. 381) also shows these three views. The side of the stool is shown in the front view, or elevation, on the left side of the drawing; the end is shown in the end view to the right, and the top of the stool is shown directly above the front view. This view is called the "plan view" or "top view." Only the framework, consisting of the four legs and rails, is shown on the plan view.

Fig. 380. Upholstered footstool

From the elevation and end view, it can readily be seen that each of the four legs is 6 in. long, 1½ in. square at the top, and 1 in. square at the base. It is also seen that the legs turn out at the base, which means that they must be cut from a piece 2¼ in. square. (See lower left-hand corner of the working drawing, Fig. 381.)

The hidden lines on each leg indicate that the rails are mortised into the legs. Their total length, 15½ and 10½ in., is given respectively on the front and end views, and their width to the right of the front view. Their thickness, ¾ in., is shown on the plan view. This view also shows that the rails are set flush with the legs. This can be verified by looking at Figure 380. The tenons are shown to be 1¾ in. wide, and the mortises are cut ½ in. below the top of the legs. (See End View.)

The two views drawn above the end view are sections showing methods of upholstering this footstool. If the stool shown were sawed through the middle, a section, such as the one shown to the right in Figure 381, would be formed. This section shows that the upholstery is fastened to a piece of plywood, and that a rabbet into which this cushion fits is cut on the inside edges of the rails and legs. This is also indicated by the hidden lines on both the elevation and end view, and by the full line on the plan view. The narrow, flat piece of molding, nailed to the top of the legs and rails, is not shown on the plan view.

323. **Footstool.** A footstool is a piece of furniture that will be welcomed in most households, because tired legs and feet find more comfort and rest when they are raised a little above the floor. The design of the stool may be varied to match different types of furniture.

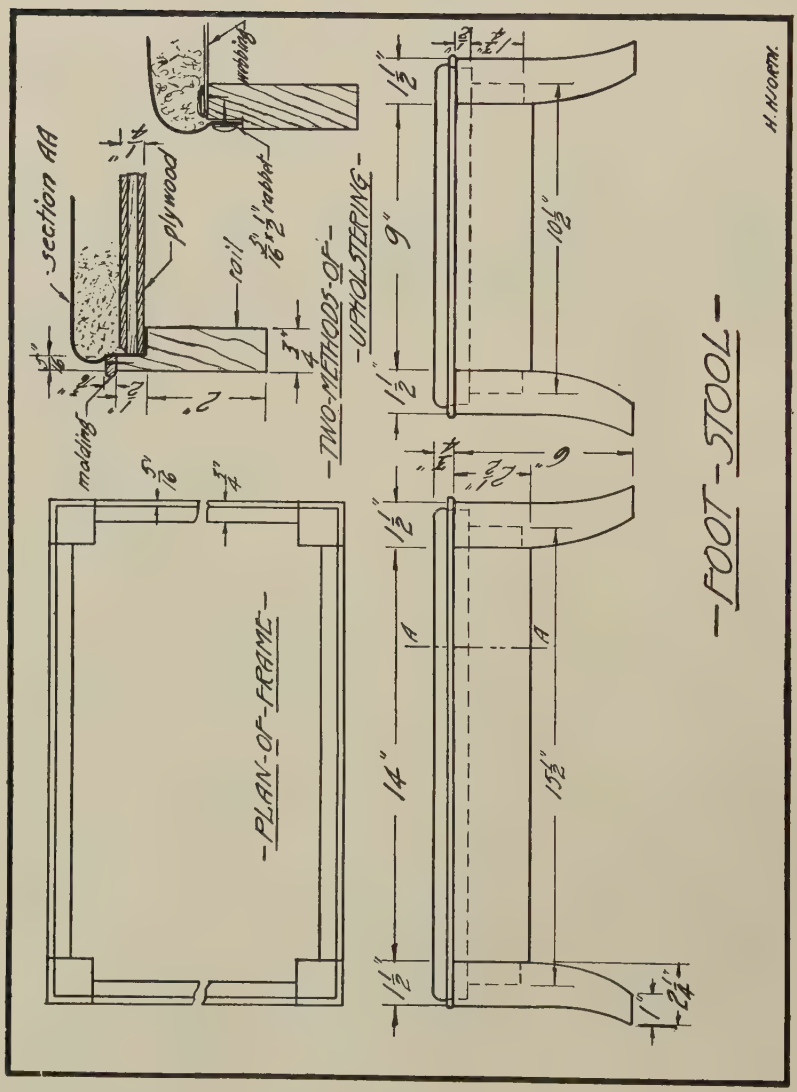


Fig. 381. Footstool

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
4	Legs	2¼	2¼	6
2	End Rails	¾	2½	10½
2	Side Rails	¾	2½	15½
1	Top (plywood)	¼	11⅜	16⅜
1½ lb. Fine Tow or Moss				
1 piece Burlap, 3 by 60 in.				
1 piece Muslin, 18 by 24 in.				
1 piece Cotton Wadding, 12 by 17 in.				
1 piece Covering Material, 18 by 24 in.				
Tacks				

SUGGESTED ORDER OF TOOL OPERATIONS

1. Square two adjoining sides on the pieces from which the legs are to be cut, and mark their shape from a template, so that the inside curves of the legs are on the square corner. (Fig. 382.)

2. Start the saw cuts at the bottom of the leg, and leave about ¼ in. of each line uncut at the top. (Fig. 382.) Saw on the lines marked on the adjoining side, following them through their entire length. The ¼ in. left of the saw cuts on the first side are now sawed, which completes the process.

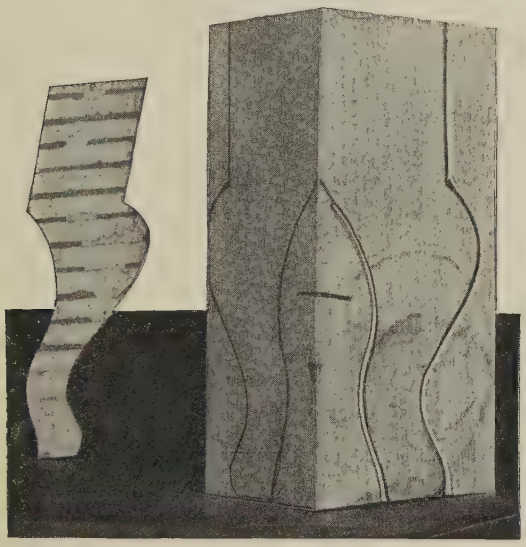


Fig. 382. Method of laying out and sawing curved legs; template is shown at the left

3. Sand the legs on the disk and spindle sander. (Arts. 227 and 229.)

4. Square the rails to dimensions (Art. 138), and lay out and cut the mortise-and-tenon joints. (Art. 164.)

5. Cut the rabbet for the seat, if it is to be a slip seat, before gluing the stool together. If the upholstery is to be tacked directly to the frame, the rabbet should be cut after the footstool is glued. (Art. 146 or 153.)

6. Glue the footstool together, as explained in Article 192.

7. Plane and smooth the legs and rails after the glue is dry.

8. Make the molding, miter it in the corners (Art. 245), and glue and nail it to the frame.

9. Upholster the stool according to directions given in Articles 255 or 256.

10. Prepare the surface for staining (Art 261), and apply water stain. (Arts. 262 and 266.)

11. Finish with a coat of shellac (Art. 268), followed by a coat of lacquer (Art. 269), and finally a coat of liquid wax. (Art. 271.)

12. Tack the covering in place, if the upholstery is made on the frame of the stool.

324. To Read the Drawing of the Early English Gate-Leg Table. Comparing the illustration of this table (Fig. 383) with the drawing (Fig. 384), a great similarity between the front view or eleva-

Fig. 383. Early English gate-leg table

tion and the illustration is immediately apparent. The five legs, connected by stretchers at the bottom and by rails at the top, are seen in both Figures 383 and 384. While Figure 383 shows the relationship of these parts, it is necessary to consult both the plan view and the elevation in the drawing in order to fully understand the construction.

The plan view represents the table in the open position. The frame-

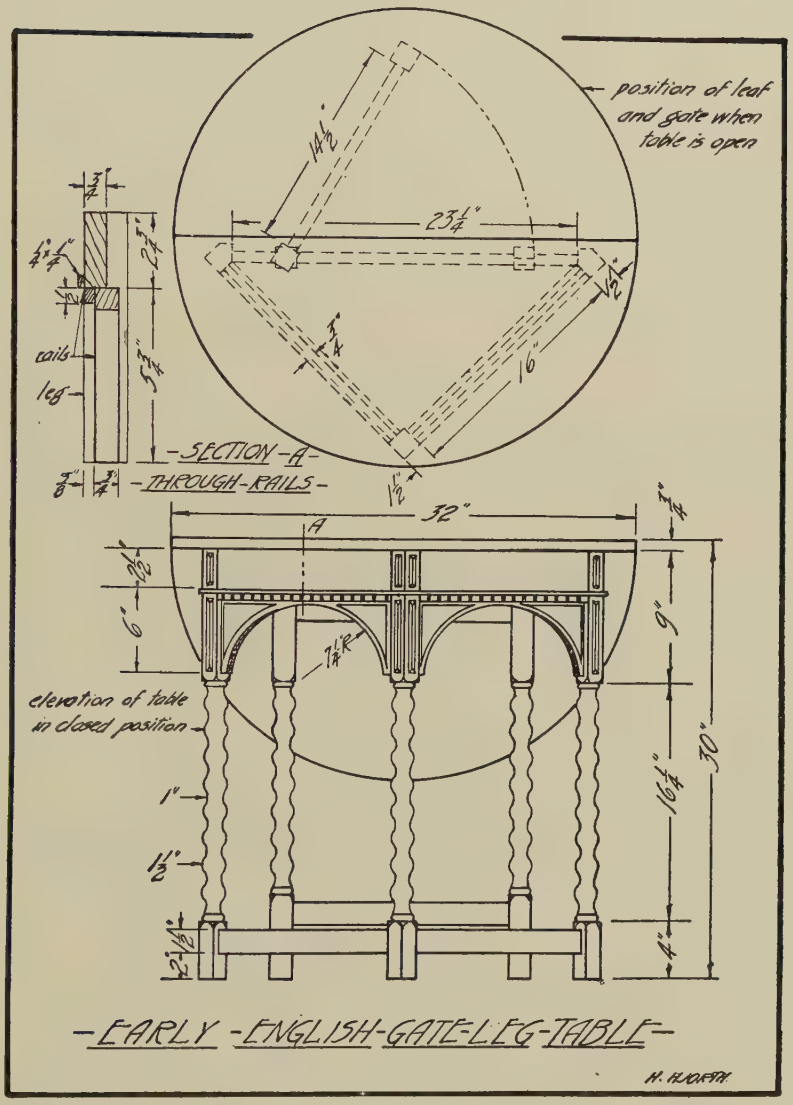


Fig. 384. Early English gate-leg table

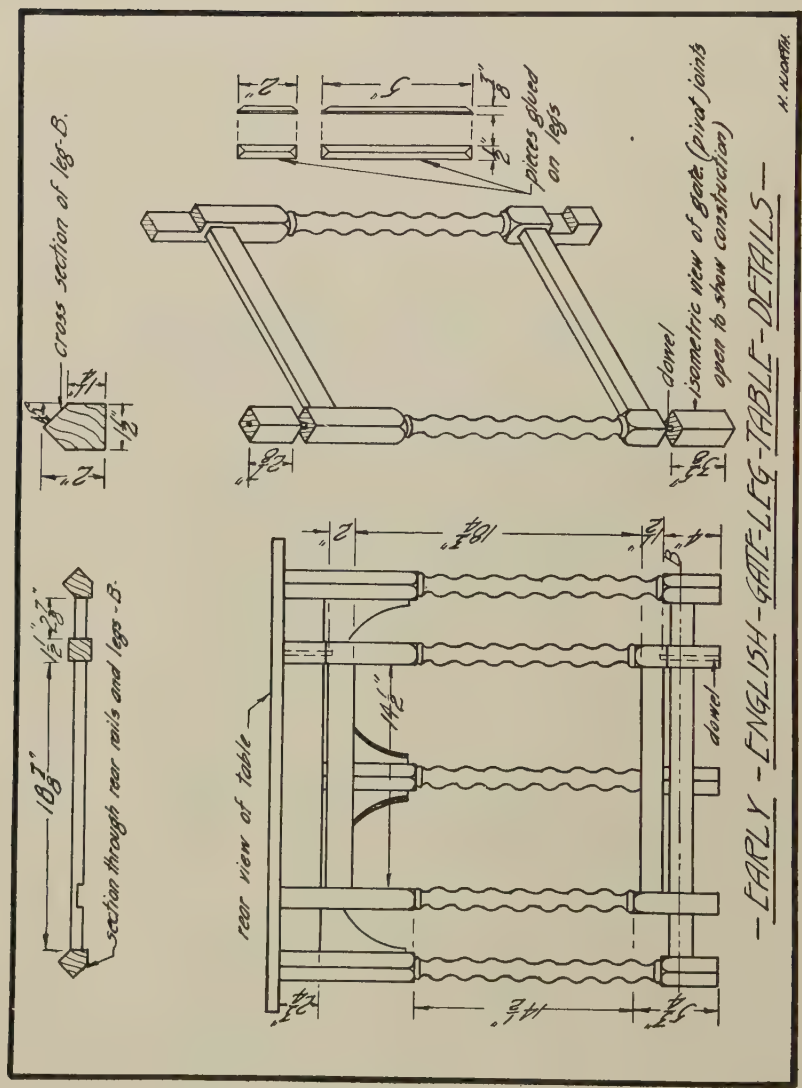


Fig. 385. Details of early English gate-leg table

work is shown in hidden lines. These hidden lines show that three of the legs are joined with rails and stretchers in the shape of a right triangle; that the other two legs are joined to this framework, and that they are movable. The details of this construction, however, are found on the second drawing, Figure 385, which gives a view of the table seen from the rear. Compare this view with Figure 386, which shows the assembly of the rear legs and the movable legs, or gate. In Figure 385, an isometric view which is a form of pictorial drawing, shows the gate more clearly. A section through the rear rails and legs and a detail of the latter give all the information necessary for the rear assembly. (Fig. 385.)

Returning to the first drawing, Figure 384, a sectional view shows the method of assembling the rails, and gives the dimensions of the various pieces of which they are composed.

The drawing, Figure 385, also has a detail of the small triangular blocks with which the legs are decorated.

Fig. 386. Rear assembly of gate-leg table

325. Early English Gate-Leg Table. The gate-leg table, which is another form of drop-leaf table, was invented during the early part of the seventeenth century. On account of its convenience and decorative value, this type of table has found favor from generation to generation. The gate-leg table shown in Figures 383 to 386, may well be used as a

card table, or wherever a small table is desirable. When the leaf is let down, the table may be placed against a wall like a console table.

Since the gate-leg table is a rather difficult project, it should not be attempted until such problems as those shown in Figures 387 to 408 have been made.

BILL OF MATERIAL

No. of pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
2	Legs	1½	1½	29¼
1	Leg	1½	1½	30
2	Legs	1½	2	29¼
2	Upper Front Rails	¾	2¾	16
2	Lower Front Rails	¾	5¾	16
2	Borders	⅜	½	16
2	Front Stretchers	¾	1½	17½
1	Rear Rail	¾	2¾	18⅞
1	Rear Rail	¾	2¾	2⅞
1	Rear Stretcher	¾	1½	18⅞
1	Rear Stretcher	¾	1½	2⅞
1	Upper Gate Rail	¾	2	14½
1	Lower Gate Rail	¾	1½	14½
1	Molding	¼	¼	40½
4	Blocks Glued to Legs	⅜	½	2
4	Blocks Glued to Legs	⅜	½	5
2	Tops	¾	16	32
3	Fast-Joint Butt Hinges			

SUGGESTED ORDER OF TOOL OPERATIONS

1. Turn the five legs according to the dimensions given in the drawing. (Arts. 142, 225, 226, and Figs. 288 and 289.) The front leg and one of the legs of the gate are exactly alike; the other leg of the gate is ¾ in. longer to allow for cutting and squaring. (See the isometric sketch in Figure 385.) The two rear legs must first be planed as shown in the cross section.

2. Make the rear assembly first. (Fig. 386.) This consists of the two rear legs, the rear rails and stretchers, and the gate.

3. Bore the holes for the dowels in both ends of the long leg before cutting the ends of it. The dowels form pivots on which this leg turns. Saw off the ends at the points indicated, and square them carefully. Insert the dowels ⅜ in. and mark the sides of the small pieces and the rest of the leg which fit together.

4. Join the two legs of the gate with rail and stretcher. Either mortise-and-tenon joints (Art. 164), or dowel joints (Art. 156) may be used. Glue these pieces together. (Art. 190.)

5. The two rear rails and the two rear stretchers are now joined to the rear legs. The short pieces, which were cut off the pivot leg, are framed in between the ends of the rails and stretchers. (Fig. 385.) Use dowel joints as explained in Article 156.

6. Place the gate in position, clamp the pieces together and mark the points where the swinging leg is to fit over the rear rail and stretcher. Cut away half the thickness of the wood at these points, both on the rail and stretcher as well as on the swinging leg. (Arts. 159 and 161.) This completes the rear assembly. Do not glue until the front rails and stretchers have been fitted to the legs.

7. Square the front rails and stretchers to dimensions. (Art. 138.)

8. The rails are built up as follows: Cut and smooth the curves on the lower part of the rails. Carve the lines as indicated in Article 250, and make the saw cuts in the ⅜ by ½ in. strip. They should be only 3/16 in. deep. Glue this strip along the upper edge of the lower rails. When dry, smooth the joint with a plane, and glue the upper rail as shown in the section in Figure 384.

9. Fasten the rails and stretchers to the legs with dowels. (Art. 156.) The upper part of the rails are set flush with the face of the legs, and the stretchers are set back ⅜ in. from the face of the legs.

10. Glue the rear assembly together. When this is dry, glue the rest of the framework together.

11. Smooth the upper part of the rails and legs with a plane, scraper, and sandpaper. Glue the raised fillet molding in place, mitering it at the corners. (Art. 245.) Also make the small triangular-shaped blocks, and glue them to the face of the legs. A good way to make these blocks is to bevel the edge of a ½-in. board, and rip it to a thickness of ⅜ in.

12. The best way to make the top is to glue up enough boards to make the total width, or 32 in., and then to square and smooth this piece. (Arts. 140 or 141.)

13. Cut this piece into halves, and joint the edges. (Art. 139.) Then place them together, and mark the circle with a pair of trammel points. (Art. 18.)

14. The top may be inlaid if desired (Arts. 234 and 235), and its edge shaped. (Art. 247.) The two halves are hinged with ordinary fast-joint butt hinges (Art. 200), unless a rule joint (Art. 182) is made. Fasten the top to the frame with cleats. (Art. 199.)

15. Prepare the surface for staining (Art. 261), and apply water stain. (Arts. 262 and 266.) If the wood is close-grain, wood filler is not

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
1	Bottom	⅜	10	18
2	Ends	⅜	1¾	10
2	Sides	⅜	1	17⅝
4 Corner Insets and 1 Center Inset				
4 ft. Line Inlay, 1/16 in. wide				

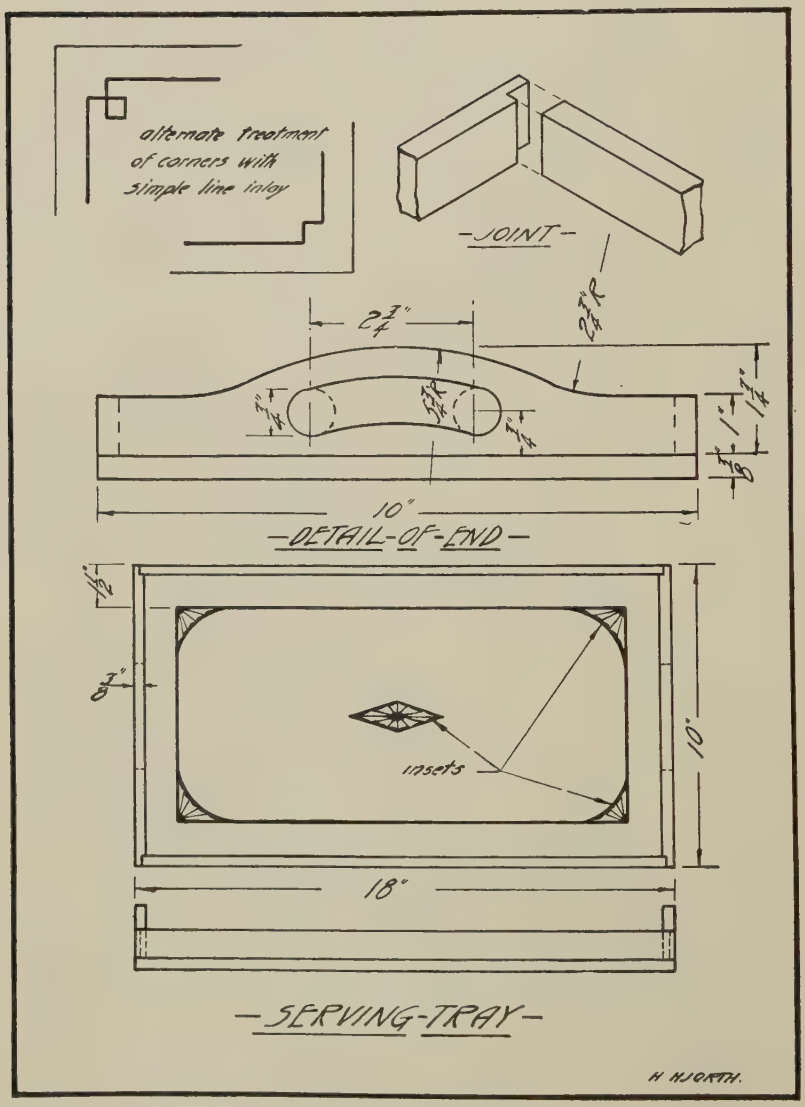


Fig. 387. Serving tray

necessary. Apply instead a coat of shellac (Art. 268), and follow that with two coats of lacquer (Art. 269) or varnish (Art. 270.)

326. **Serving Tray.** A serving tray is a very useful article in any household. The tray may be perfectly plain, or it may be made more attractive by the application of inlay, decalcomania transfers, or other types of decoration. (Figs. 387 and 388.)

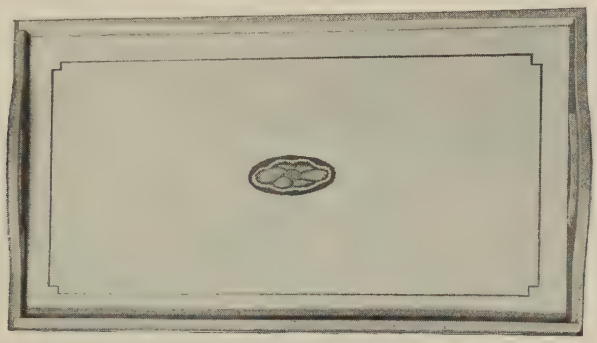


Fig. 388. Inlaid Serving Tray

SUGGESTED ORDER OF TOOL OPERATIONS

1. Square the four pieces for the frame to dimensions. (Art. 138.)
2. Lay out the shape of the end pieces on one of these, and nail the two together outside the lines marked.
3. Bore a series of ¾ in. holes to form the handle. Chisel away the projections left by the bit, and smooth with a file and sandpaper.
4. Cut the curve with a turning saw or on a band saw.
5. Make the rabbet joints as explained in Article 146 or 151, and glue the frame together as shown in Figure 238.
6. Make the bottom from a piece of plywood or from solid stock (Art. 140), and cut it to dimensions.
7. Inlay the lines and insets. (Arts. 233, 234, and 235.)
8. Glue the frame to the bottom by clamping it with hand screws.
9. When the glue is dry, plane and smooth the outside of the tray, and prepare the surface for staining. (Art. 261.)
10. If the tray is made of mahogany, it is recommended to stain it with lime water. (Art. 265.)
11. When the surplus lime has been removed, the tray is given a coat of wood filler. (Art. 267.)
12. This is to be followed by a thin coat of shellac (Art. 268), and by two or three coats of a varnish that will not mar easily. (Art. 270.)

327. **Mirror Frame.** Centuries ago, it was a sign of wealth to possess a mirror. Today even the poorest home can have a mirror of

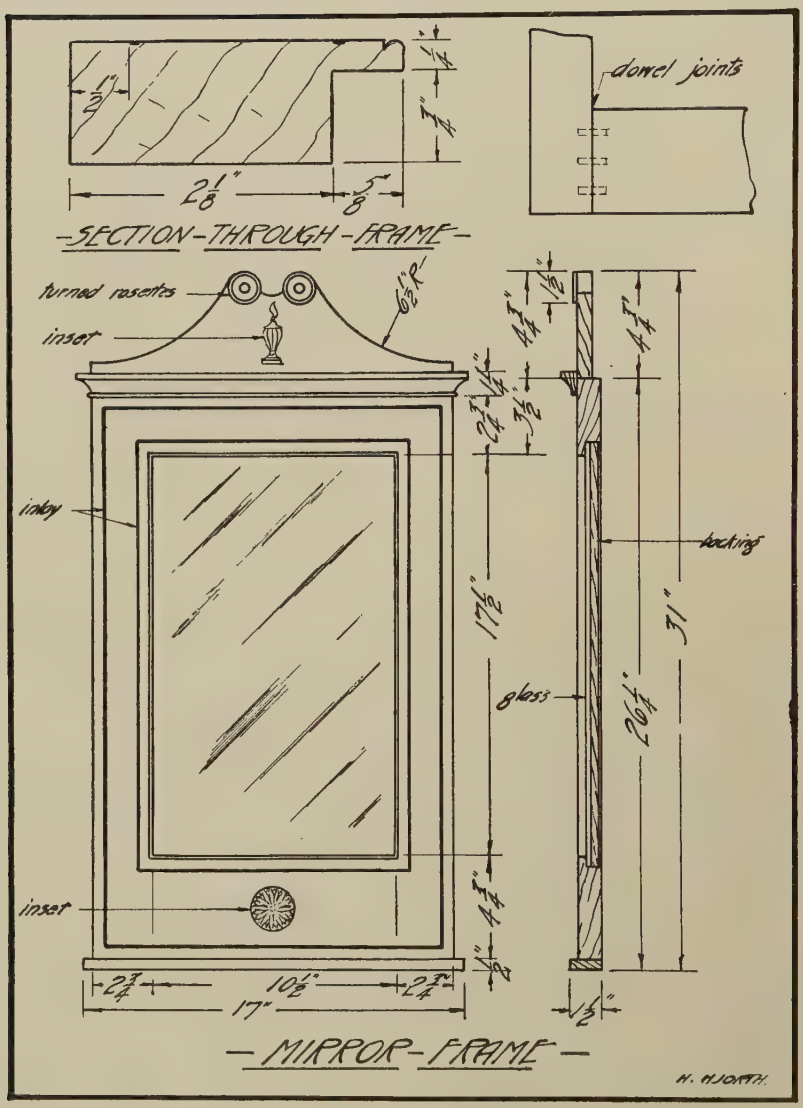


Fig. 389. Mirror frame

some kind. Mirror frames vary from the plainest to the most elaborate. A mirror, like the ones illustrated in Figures 389 and 390, may be hung in a living room, in a hall, over a console table, or in a bedroom over a chest of drawers.

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
2	Sides	1	2¾	25¾
1	Upper Rail	1	3½	10½ } if frame is
1	Lower Rail	1	4¾	10½ } doweled together
1	Bottom	½	1½	17
1	Top	¾	4¾	16
1	Molding	¾	1¼	24
1	Backing	⅜	12	19
2	Rosettes, 3/16 by 1½ in. diam.			
2	Insets and 4 yd. Line Inlay, 1/16 in. wide			
1	Plate Glass, ¼ by 11¾ by 18¾ in.			

SUGGESTED ORDER OF TOOL OPERATIONS

1. Square the sides and rails to dimensions. (Art. 138.)
2. Cut the rabbet on the back of the pieces (Art. 146), remembering that on the side pieces it stops 2 in. from one end and 4 in. from the other if the frame is doweled together.

If it is desired to make an end-lap joint with rabbet, follow directions in Article 160. In this case, the upper and lower rails should be 16 in. long.

3. Lay out and make the dowel joints according to directions given in Article 156.
4. Glue the frame together (Art. 190), and plane it flat and smooth when it is dry.
5. Make the bead along the inside edges of the frame (Art. 241), and inlay the lines and inset. (Arts. 234 and 235.)
6. Lay out and cut the top piece according to the drawing.
7. Inlay the inset in the top piece (Art. 235), turn the rosettes, and glue them in place. The rosettes are turned on a faceplate or

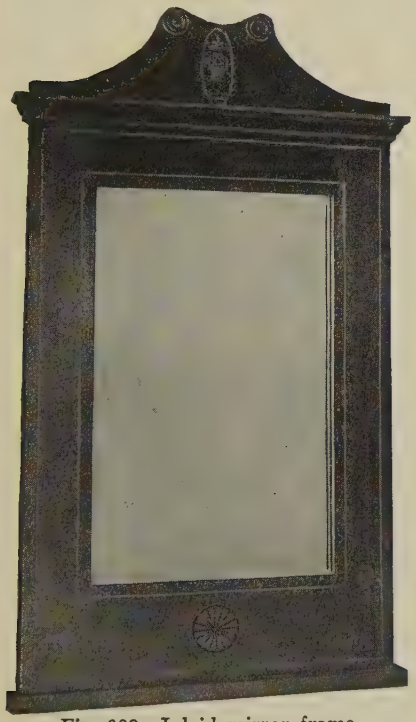


Fig. 390. Inlaid mirror frame

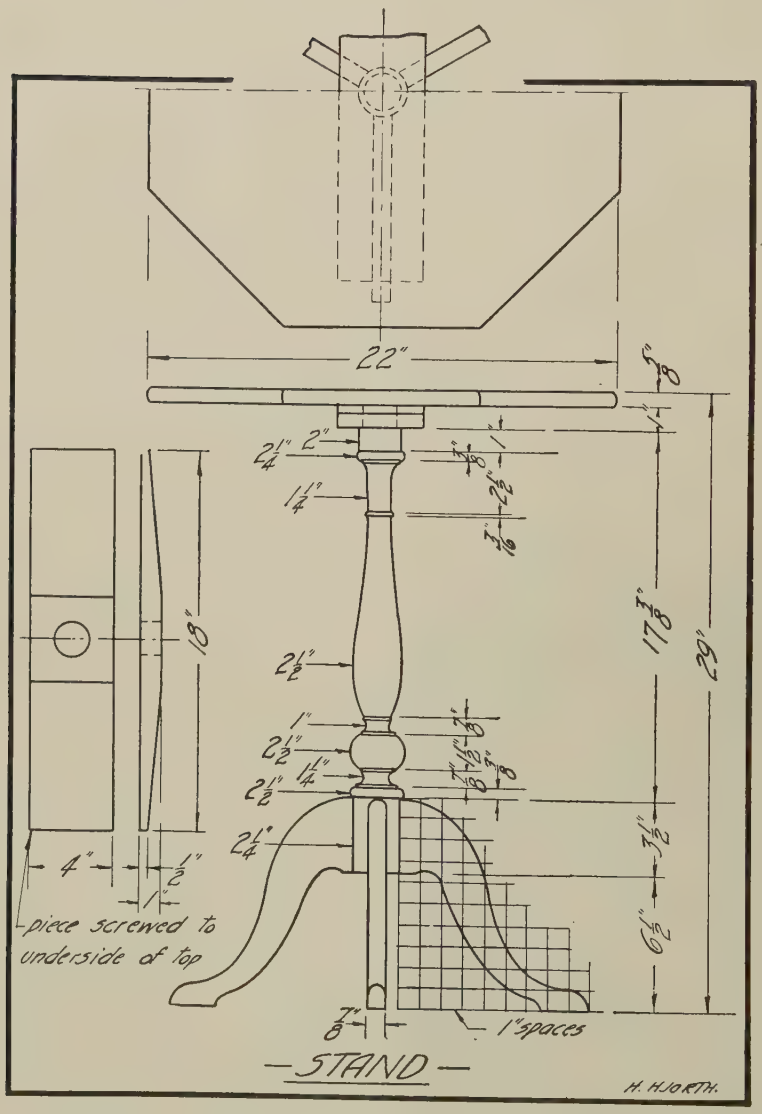


Fig. 391. Stand

a screw chuck. (Art. 228.) When one is finished, it is cut off with a parting tool, and the next one turned from the remaining piece of wood.

8. Glue the top piece to the upper rail, so that their faces are flush.

9. Make the molding, miter it in the corners, and glue it in place. (Arts. 244 and 245.)

10. Prepare the surface preparatory to staining. (Art. 261.)

11. If the frame is made of mahogany, stain it with limewater. (Art. 265.)

12. Remove all traces of lime from the surface, and follow with wood filler (Art. 267), a coat of shellac (Art. 268), a coat of lacquer (Art. 269), and a coat of liquid wax. (Art. 271.)

328. Stand. Small tables are not only used for many different purposes in the modern home, but they are also of considerable decorative value. The stand (Figs. 391, 392, and 393) described in the following may be made either with a fixed or a tilting top. The latter type of table is more decorative, and takes up less room when not in use.

Fig. 392. Stand with round tilting top

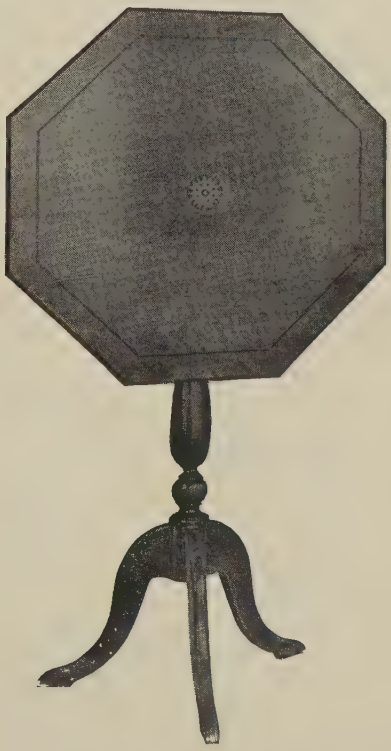


Fig. 393. Stand with octagonal tilting top

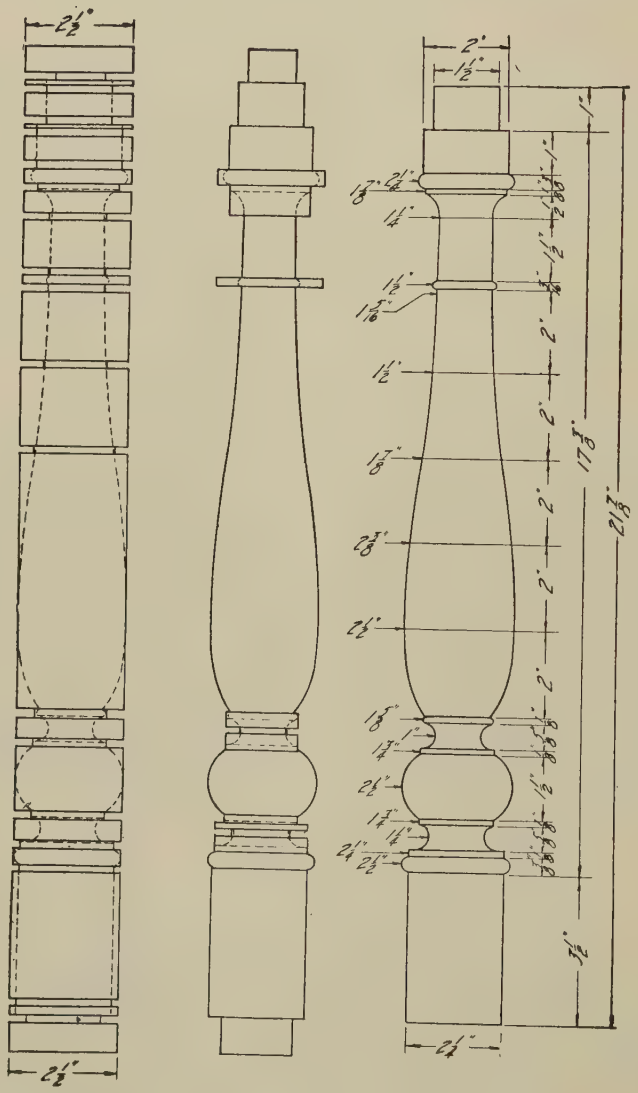


Fig. 394. Turning details

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
1	Column	2½	2½	21⅞
3	Legs	⅞	4	13½
1	Top	⅝	22	22
1	Cleat	1	4	18—for fixed top
2	Cleats	⅞	1	18 } for tilt top
1	Block	1	6	6 } for tilt top
1 Inset				
5 ft. Line Inlay ⅛ in. wide				
1 Table Catch for Tilting Top				

SUGGESTED ORDER OF TOOL OPERATIONS

1. Turn the column according to the method shown in Figure 394. (Arts. 225 and 226.)

2. Make a pattern of the leg by ruling off a piece of cardboard in 1-in. squares, and tracing the lines as shown in Figure 391. Cut the legs with a turning saw or on a band saw, and sand them smooth on the spindle sander as explained in Article 227. (Fig. 291.)

3. Round their upper edges as shown in Figure 326.

4. Make the doweled butt joint (Art. 157 and Fig. 184), sanding the ends of the legs as in Figure 292.

5. If it is desired to reed the column, this operation should be done

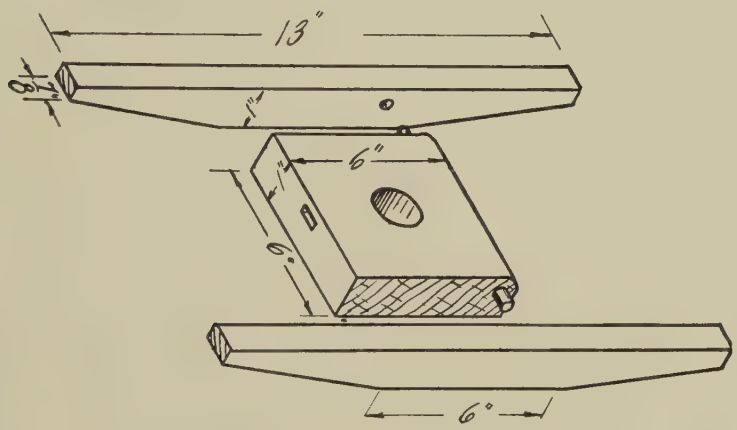


Fig. 395. Tilting mechanism

before the legs are glued. Straight reeds (Art. 236) may be carved on the portion which is 10 in. long, and spiral reeds (Art. 237) may be carved on the ball-shaped piece below it.

6. The legs are now glued to the column (Art. 196), one at a time, as illustrated in Figure 242.

7. The boards for the table top are jointed as explained in Article 139, after which they are glued as shown in Figure 232. (Art. 189.)

8. The top is now squared (Arts. 140 or 141), and its edge shaped as explained in Article 247. The top may be made round (Fig. 392), octagonal (Fig. 393), elliptical, etc.

9. The lines and inset are then inlaid. (Arts. 234 and 235.)

10. If the top is to be fixed, a cleat 1 by 4 by 18 in. is made as shown in the detail (Fig. 391), and a hole 1½ in. in diameter bored in its center so that it will fit over the end of the column. This cleat is glued to the column, and then screwed to the underside of the table, across the grain.

11. If the top is to tilt, two cleats and a block are made according to the detail drawing, Figure 395.

12. Two ⅜-in. dowels are glued into one end of the block near one of its edges. The block is centered between the cleats, and corresponding holes are bored in these to a depth of ½ in. The upper edge of the block is rounded, so that it can move freely when the cleats are held against a flat surface.

13. In assembling, screw one of the cleats to the underside of the top across the grain. Glue the block to the top of the column so that its rounded edge is up. The block should be so placed on the column that the top when tilted, will be at right angles to one of the legs. (Figs. 392 and 393.)

14. The top is now placed face down on the bench. The column, with the block glued to it, is placed in position on the top, and the remaining cleat screwed in place. A table catch (Art. 206) is screwed to the top, and locks it in a horizontal position.

15. The table is now ready for the finish. Go over the surface carefully (Art. 261), and give it a water stain as explained in Articles 262 and 266. The tables illustrated were made of birch and given an amber-colored stain. They were then shellacked (Art. 268) and given two coats of clear lacquer. (Art. 269.) The last coat of lacquer was rubbed down with powdered pumice stone and oil.

329. Lamp Standard. Turned projects are always very interesting. Take, for example, lamp standards. These are particularly desirable as the work of wiring them for electric light adds another element of interest. (Figs. 396, 397, and 398)

SUGGESTED ORDER OF TOOL OPERATIONS

1. Square the upright to dimensions, and mark the centers very carefully on each end.

2. The hole for the wires should be ⅜ in. in diameter, and must be bored from both ends. It is recommended to bore it in a lathe or a drill press, and to use a machinist's twist drill. It can also be bored with an ordinary brace and auger bit having a quick-boring screw. (Art. 59.) One person should sight the bit (Fig. 177), while another

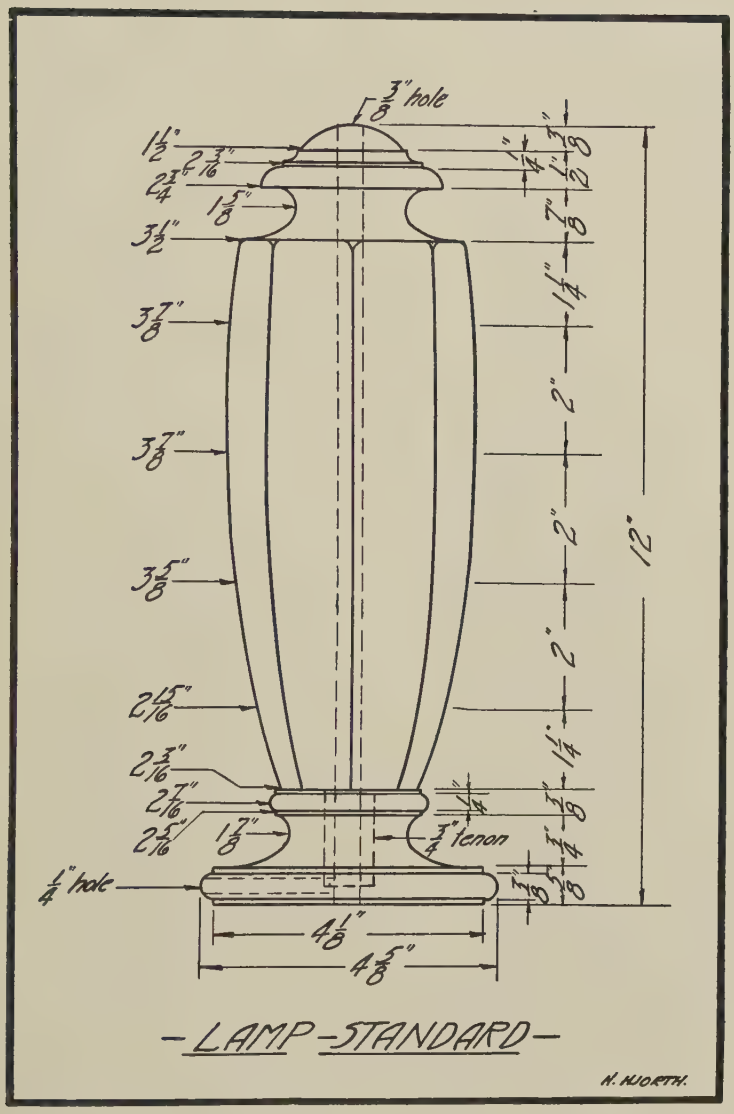


Fig. 396. Lamp standard

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
1	Upright	3⅞	3⅞	11½
1	Base	1¾	4⅝	4⅝
1 Brass Bushing, ⅛ in.				
1 Brass Nipple, ⅛ by 2 in.				
1 Two-Light Fixture				
2 Pull Sockets				
7 ft. Lamp Cord				
1 Plug				

Fig. 397. Table-lamp standard

Fig. 398. Reeded table-lamp standard

does the boring. If the holes should not meet exactly in the center, any unevenness may be burned away with a red-hot, ¼-in. iron rod.

The upright may also be made of two pieces glued together. In this case, a groove 3/16 by ⅜ in. is cut in the center of each piece before they are glued.

3. Plug the hole in one end of the upright with a piece of ⅜-in. dowel rod, and let the other end run on the dead center. Turn according to directions given in Articles 223, 225, and 226.

4. Divide the turned upright into six or eight parts by wrapping a strip of paper around it as shown in Figure 306, and gauge horizontal lines at these points as shown in Figure 307.

5. Hold the upright in a bench vise, and plane the faces flat with an ordinary jack plane. Finish with scraper and sandpaper.

6. Turn the base as explained in steps 1 to 4, Article 230, but complete the turning of the lower part of it before removing it from the face plate. Make the chuck as explained in steps 4 to 6, Article 230, but in this case cut the recess at least ⅜ in. deep.

7. Glue the base and upright together, clamping them in the lathe.

8. The lamp is now stained as explained in Article 262. It is then given a coat of wood filler (Art. 267), followed by a coat of shellac. (Art. 268.) This may be rubbed down on the base while the lamp is revolving at low speed in the lathe. It may now be given two coats of lacquer (Art. 269), which may also be rubbed down with powdered pumice stone and oil.

9. Tie the lamp cord to the wire inserted in the lamp when gluing, and pull it through. Screw the two-light fixture to the end of the nipple, splice two wires to the lamp cord near its end, and connect the two pull sockets. Connect the other end of the lamp cord to a plug.

10. A piece of felt or velvet may be glued to the bottom of the lamp base so that it may stand on a highly polished surface without scratching it. Apply glue to the base *and not to the cloth.* Press the cloth in place with the hands, and let it stand to dry. When the glue is dry, cut the cloth even with the base with a pair of scissors.

This lamp standard may also be decorated by straight reeding (Fig. 398 and Art. 236), or spiral reeding. (Art. 237.)

330. End Table. A table of the kind shown in Figures 399 and 400, is very conveniently placed at the side of an armchair or at the end of a sofa. The trough serves as a receptacle for books. Books may also be placed on the top of the table together with a lamp, vase, or ash tray, according to the taste and desire of the owner.

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
4	Legs	1½	1½	26¼
2	Rails	¾	2½	10
2	Rails	¾	2½	24
2	End Pieces	¾	8½	8
1	Trough	½	4	24
1	Trough	½	4½	24
1	Top	¾	13	27
1 Inset				

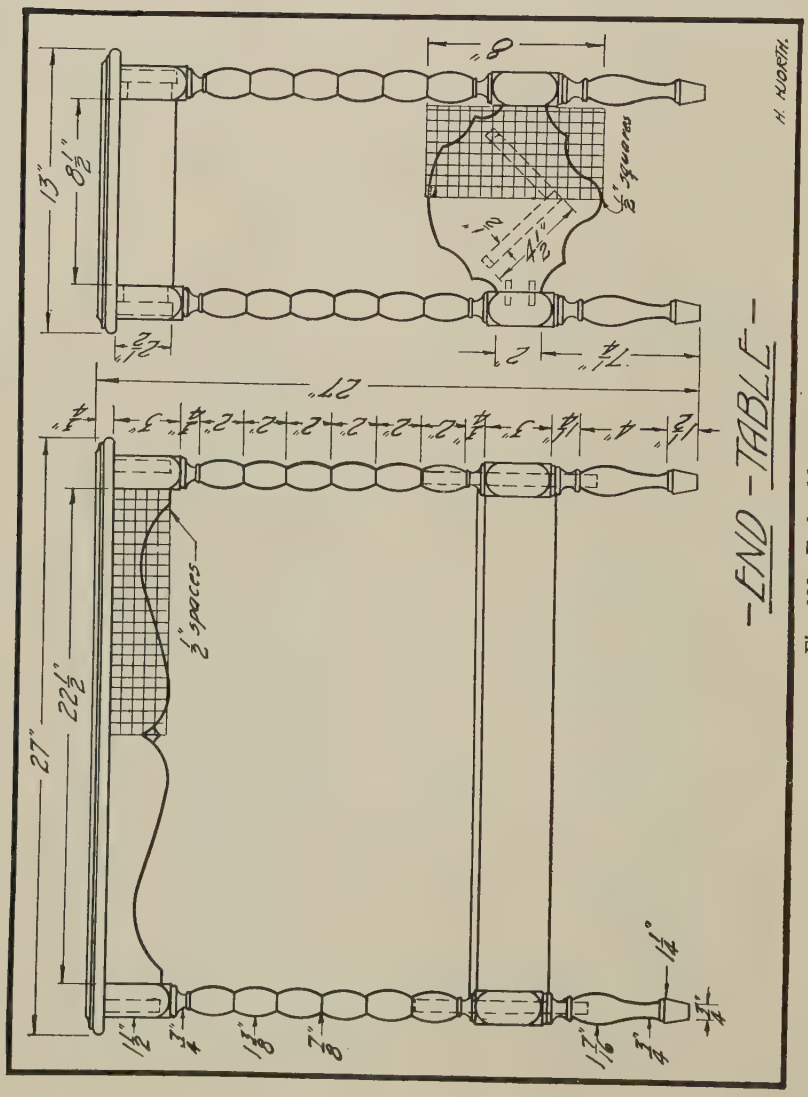


Fig. 399. End table

SUGGESTED ORDER OF TOOL OPERATIONS

1. Turn the four legs as explained in Articles 225 and 226. See also Figures 289 and 290 for the method of turning square parts.

2. Plane the square parts of the legs to size. (Art. 142.)

3. Get out the stock for the rails, end pieces, and book trough, and square them to dimensions. (Art. 138.)

4. Lay out and chisel the gains (Art. 148) in the end pieces before cutting them to shape.

Fig. 400. End table with book trough

5. Make a template of cardboard by ruling it off as shown in Figure 399, and trace the outline of the end pieces.

6. Nail these on the waste side of the lines, and saw with a turning saw or on a band saw. Smooth the edges with a file and sandpaper, holding the pieces together with a hand screw.

7. Lay out and make the doweled butt joints as explained in Article 156.

8. Mortise the rails into the legs. (Arts. 164, or 168 and 169.)

9. Glue up the two ends, and hand screw them together to avoid twisting of the legs. (Art. 192 and Fig. 234.)

10. When dry, glue the side rails and book trough to the ends, and test for squareness. (Art. 192.)

11. Joint the boards for the top (Art. 139), glue them together (Art. 189), and square the top. (Art. 140 or 141.)

12. Apply the inset as explained in Article 235. If the wood for the top is beautifully figured, line inlay may be omitted. (Fig. 401.)

13. Shape the edges of the top. (Art. 247.)

14. Fasten the top to the rails by cleats. (Arts. 198 and 199.)

15. Prepare the surface for staining (Art. 261), apply water stain (Art. 262), and follow this by a coat of shellac (Art. 268), and two coats of clear lacquer (Art. 269) or varnish. (Art. 270.)

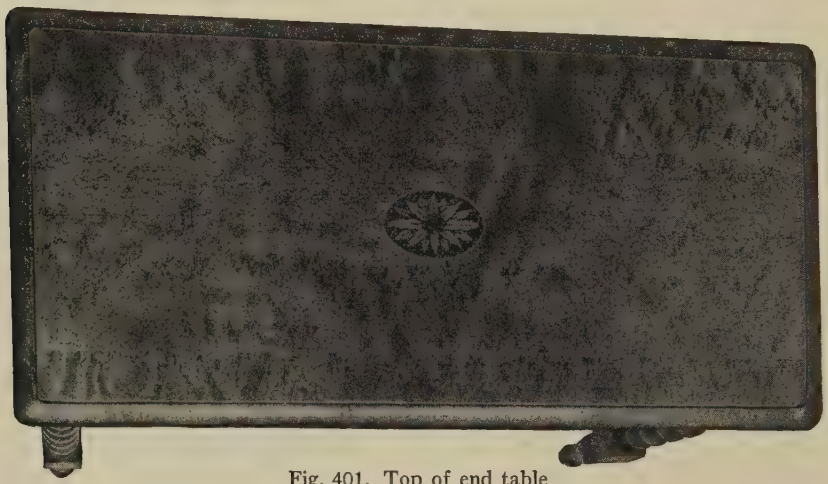


Fig. 401. Top of end table

Wood filler may be omitted if the wood is close-grained.

331. **Stool.** The stool shown in Figures 402 and 403 is essentially a project in applied wood turning. With its rush-woven seat, it makes a very attractive and convenient piece of furniture.

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
4	Legs	1¾	1¾	17¼
8	Stretchers	1⅛	1⅛	16¼
4	Rails	1⅛	1 9/16	16¼
2 lb. Art Fiber for Rush Seats, 6/32 in.				

SUGGESTED ORDER OF TOOL OPERATIONS

1. Turn the legs and stretchers between centers as explained in Articles 225 and 226. See also Figures 289 and 290 for method of turning square parts.

2. Plane the square parts of the legs to size as explained in Article 142.

3. Turn a ¾ in. tenon on each end of every stretcher, and bore corresponding holes in the legs. (Fig. 177.)

4. Mortise the rails into the legs as shown. See Article 164.

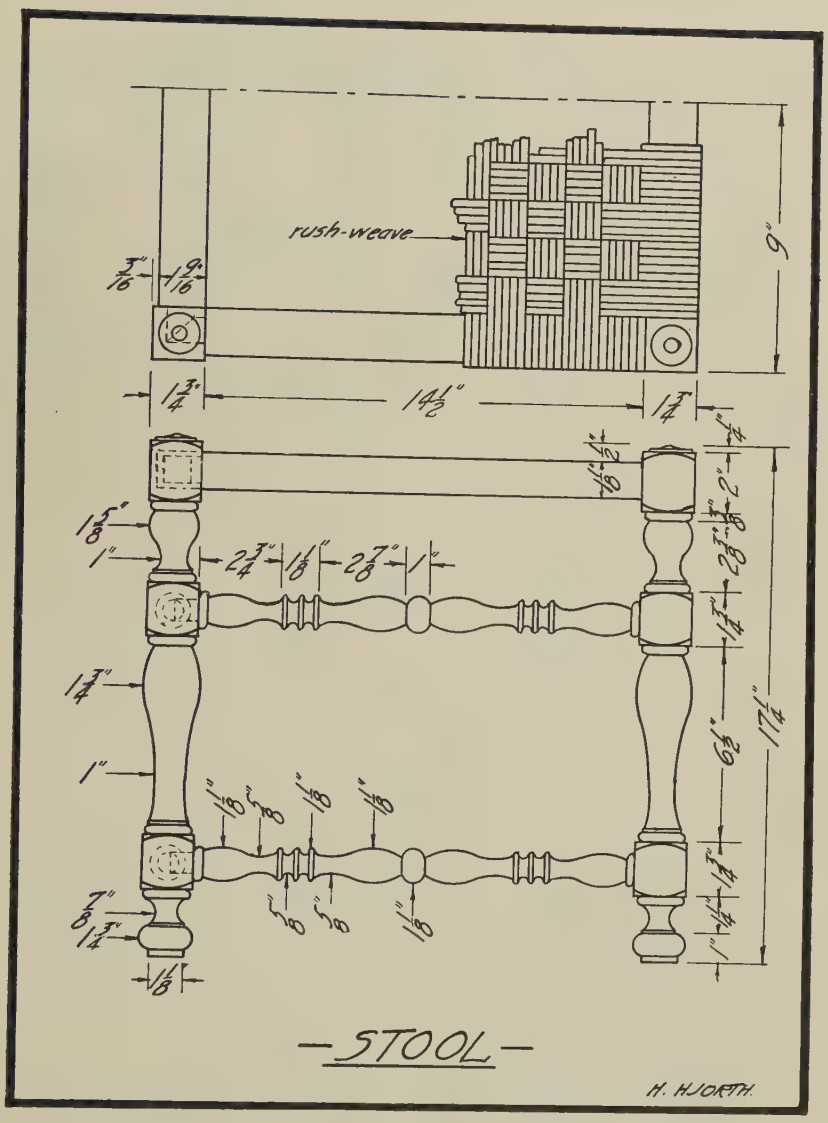


Fig. 402. Stool

5. Round the edges of the rails with rough sandpaper so that they will not cut through the fiber.

6. Stain and finish the turned parts in the lathe. If the stool is made of a hard, close-grain wood like maple, apply one coat of water stain (Art. 262), one coat of shellac (Art. 268), and two coats of lacquer. (Art. 269.) Rub down between coats with fine steel wool or powdered pumice stone, letting the lathe revolve at its lowest speed.

Fig. 403. Stool with turned legs and stretchers, and rush seat

7. Glue two opposite sides, protecting the finished surfaces with soft-wood blocks. (Art. 192.) Hand screw together as shown in Figure 234.

8. Glue the remaining rails and stretchers between these two sides, and test for squareness. (Art. 192 and Fig. 236.)

9. Weave the seat as explained in Article 257.

332. **Occasional Table.** The occasional table is a drop-leaf table, which, as its name implies, can be used for many different purposes or occasions. The construction of this table may be made extremely simple as shown in Figure 405, or it may be elaborated as suggested in the drawing, Figure 404. It may be made to serve as a kitchen table, or it may be made to grace a living room.

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
4	Legs	1½	1½	29¼
2	Rails	¾	5	25½
4	Brackets	¾	5	3½
4	Brackets	¾	5	8½
4	Division Rails	¾	1½	9½
4	Bearing Rails	¾	2	24
1	Top	¾	13½	31
2	Top	¾	9½	28½
2	Drawer Fronts	¾	3½	8
4	Drawer Sides	½	3½	13
2	Drawer Ends	½	2¾	7½
2	Drawer Bottoms	¼	7½	13¼
2	Drawer Knobs			
4	Piano Hinges, 5 in. long			

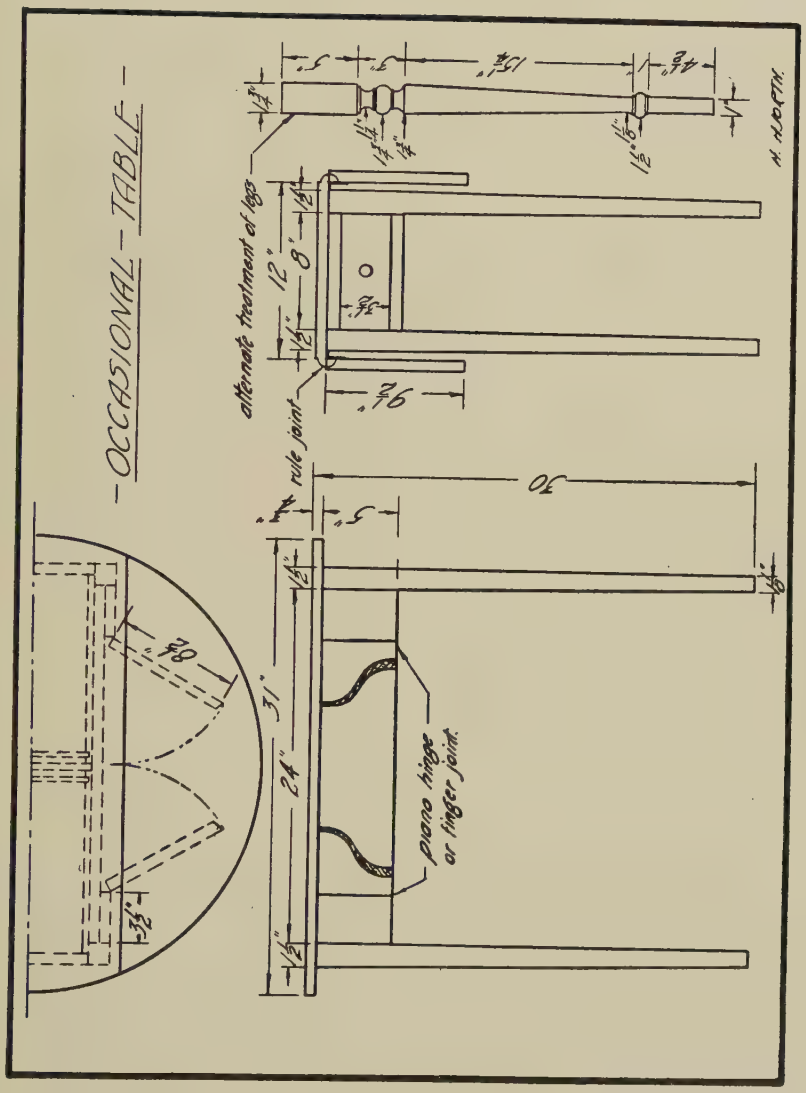


Fig. 404. Occasional table

SUGGESTED ORDER OF TOOL OPERATIONS

1. Square and taper the legs to dimensions. (Art. 142, 143, or 144.) If turned legs are used, they should be made according to directions given in Articles 142, 225, and 226. They may also be reeded to make them more decorative. (Art. 236.)

2. Mortise the long rails and the lower division rails into the legs. (Arts. 164 and 165.)

3. The upper division rails should be let into the tops of the legs with a half-lap dovetail joint. (Art. 162.)

4. Glue the two long sides together (Art. 192), and hand screw them to prevent twisting of the legs. (Fig. 234.)

5. Glue and screw the bearing rails for the drawers to the table rails, so that they come flush with the upper and lower edges of the latter. (Art 175.)

6. Glue the table together and test for squareness. (Art. 192.)

7. Construct and fit the drawers. (Arts. 172, 174, and 175.)

8. Make the brackets and glue them to the rails as shown. A piano hinge or continuous hinge may be substituted for the finger joint (Art. 183), but the latter is the best method.

Fig. 405. Occasional table

9. Make the three pieces for the top. (Arts. 139, 189, and 140 or 141.)

10. The leaves may be hinged with three hinges on each side (Art. 200) so that they form an ordinary butt joint. A rule joint (Art. 182) should be made on a better class of table.

11. The middle section of the top is screwed to the upper bearing and division rails. (Art. 199.)

12. If the table is to be used as a breakfast table or in a child's room, it would be appropriate to paint it (Arts. 274 to 278), and perhaps to decorate it with decalcomania transfers. (Art. 251.)

13. If the table is made of mahogany, it may be stained with water stain (Art. 262), or bichromate of potassium. (Art. 265.) (See also Arts. 261 and 266.) This may be followed by a coat of wood filler (Art. 267) and several coats of linseed oil. (Art. 272.)

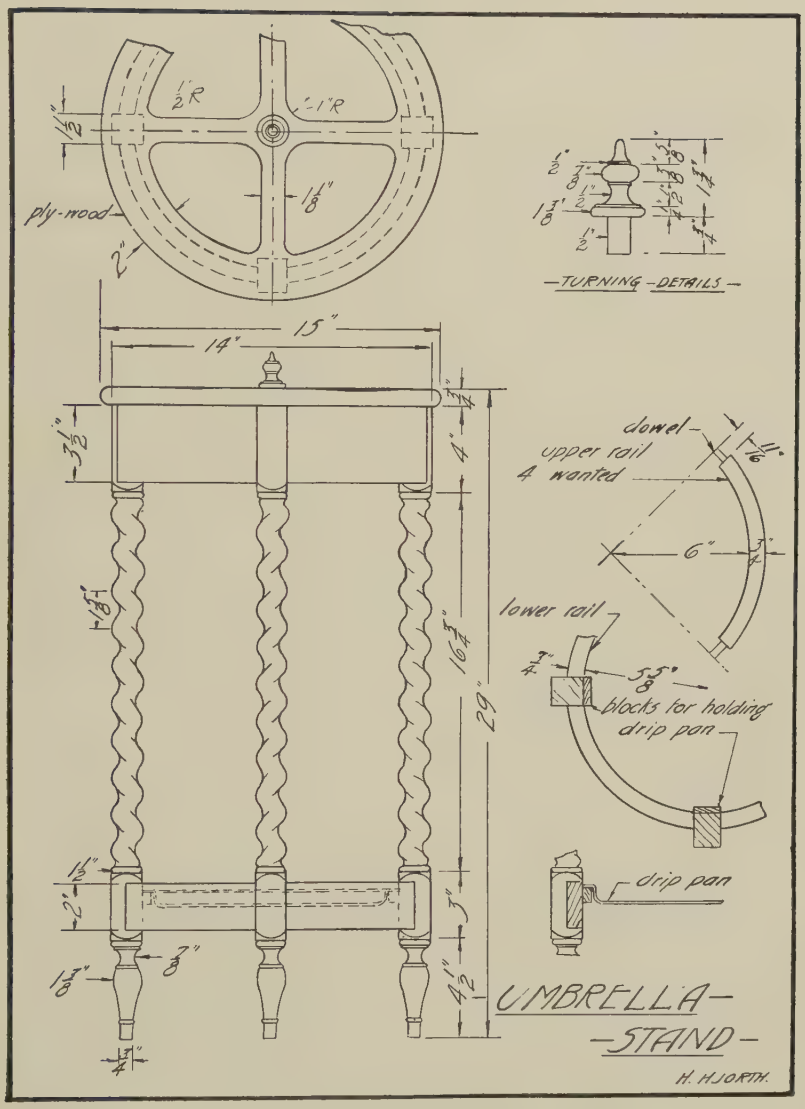


Fig. 406. Umbrella stand

333. Umbrella Stand. An umbrella stand is a piece of furniture that usually receives scant attention, and on the construction of which little time and effort are expended. The one illustrated in Figure 406 is a little more ornate than the usual run of umbrella stands. The drawing can be easily changed into a small table or a stand for a statue, a large vase, or a flower pot.

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
4	Legs	1½	1½	28¼
2	Four Upper Rails	4	3½	9
2	Four Lower Rails	2	3½	9
1	Top	¾	15	15
1	Turned Knob	1⅜	1⅜	2½
1 Drip Pan, 11 in. in diameter				

SUGGESTED ORDER OF TOOL OPERATIONS

1. Turn the legs according to directions given in Articles 222, 225, and 226. See also Figures 289 and 290 for turning square parts.

2. Plane the square parts of the legs to size. (Art. 142.)

3. Lay out and carve a single spiral on each of the legs (Art. 238.) Note that the spiral runs in opposite directions on every other leg.

4. Make a template of the upper and lower rails, and cut these on the band saw. Sand them smooth on the spindle and disk sander. (Arts. 227 and 229.)

5. Cut the angles on the curved rails, preferably on a wood trimmer (Art. 102), and fit them carefully on full-size plan views, such as are shown in part in Figure 406.

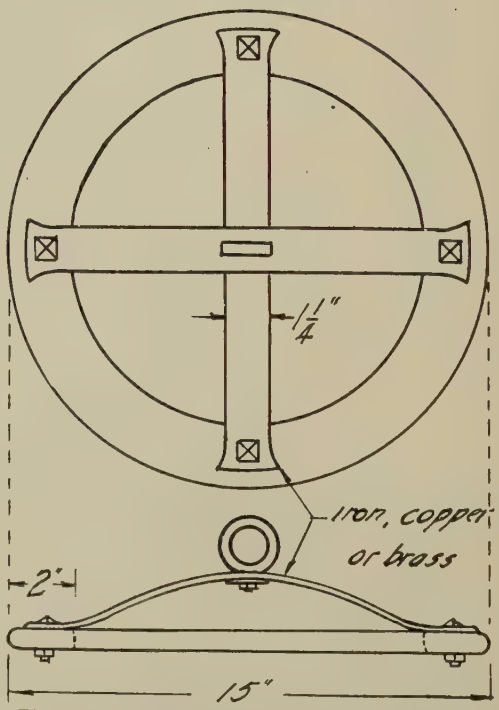


Fig. 407. Alternate method of constructing top of umbrella stand

6. Lay out and bore the holes for the dowels as explained in Article 156 and Figures 177 and 182.

7. Glue the rails and legs together (Art. 196), and tighten the joints with a column clamp (Fig. 83), or by twisting a rope. (Fig. 241.)

8. The top may be sawed out from a solid piece of wood or from a piece of plywood.

See detail of alternate method of making the top in Figure 407.

9. A turned finial is glued in the center of the top.

10. The drip pan rests on four blocks fastened to the inside surface of the legs as shown in Figure 406.

11. To minimize the bad appearance of the plywood edge of the top, it is suggested to bead it as shown in Figure 327. It may also be stained darker than the rest of the stand.

12. If the stand is made of a hard close-grained wood, give it a coat of water stain (Art. 262), followed by a coat of shellac (Art. 268) and two coats of lacquer (Art. 269) or varnish (Art. 270).

334. Cabinet. A cabinet may be used for many different purposes, such as a radio cabinet, a music cabinet, a receptacle for phonograph records, music rolls, silver, curios, etc. The design of the cabinet as shown in Figure 408 is typical of the early English type of furniture made in the beginning of the seventeenth century. This period of furniture design, the Jacobean, has been widely reproduced and adapted to modern needs.

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
4	Legs	1¾	1¾	31¼
2	Sides	¾	12¾	14
1	Back	¾	14	20¾
2	Front Rails	¾	1¾	21½
2	Front Stretchers	¾	1¾	21½
2	Side Stretchers	¾	1¾	13½
1	Bottom	¾	13¾	22
4	Cleats	¾	¾	12
2	Cleats	¾	¾	20
2	Door Rails	1	2¼	17½
2	Door Stiles	1	2¼	12½
1	Door Panel	½	8¾	16¼
1	Panel Block	½	2½	4
2	Panel Block	½	¾	2¾
2	Panel Block	½	¾	5¾
2	Split Turning	¾	1½	12
10 ft. Molding, ½ by ¾ in.				
1 pair Hinges				
1 Lock and Escutcheon				

SUGGESTED ORDER OF TOOL OPERATIONS

1. Get out the stock for the legs and turn them as shown in Figure 408. (Arts. 142, 225, 226, and Figs. 289 and 290.)

2. Square the sides, back, stretchers, and rails to dimensions. (Arts. 138 to 141.)

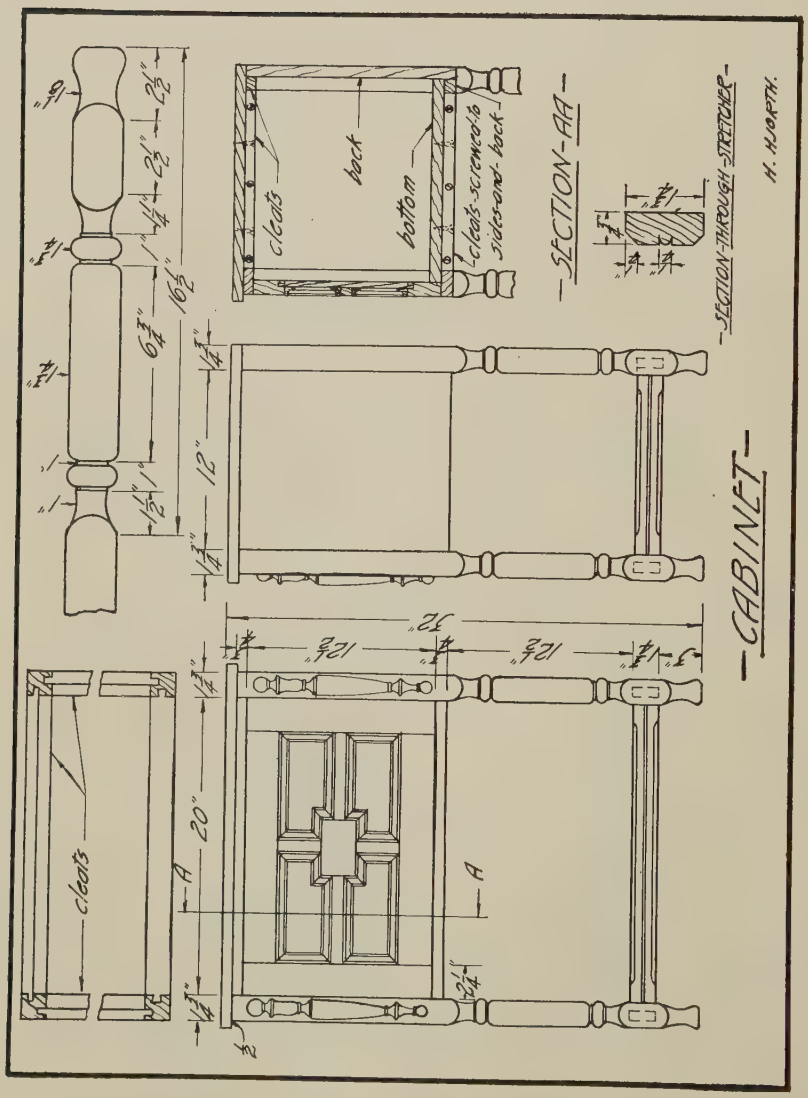


Fig. 408. Cabinet

3. Plane the chamfers and carve the bead on the stretchers. (Arts. 241 and 242.)

4. Lay out and cut the mortises and tenons on the stretchers and the lower rail. (Art. 164 or 168 and 169.)

5. Fit the upper rail into the top of the front legs with a half-lap dovetail joint. (Art. 162.)

6. Fit the sides and back to the legs with a rabbet and groove joint. (Arts. 150, 152, 153, and Fig. 173.)

7. Glue the two sides of the cabinet and hand screw them together. (Art. 192.)

8. Plane and smooth the sides, and glue them together with the back, the two stretchers, and the two rails. (Art. 192 and Fig. 236.)

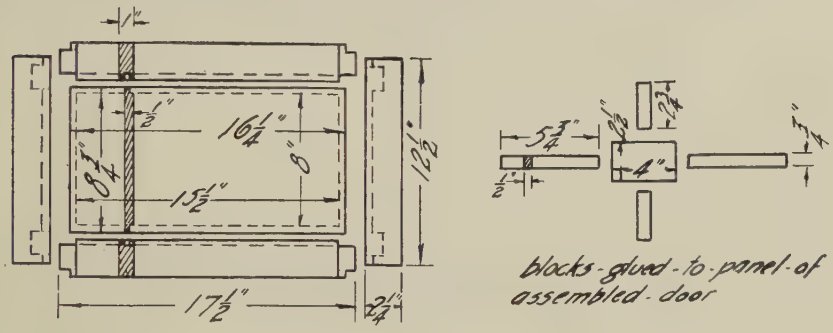


Fig. 409. Details of cabinet door

9. Make the cleats, and screw them to the sides and back as explained in Article 198.

10. Make the bottom, fit it in place, and screw it to the lower three cleats. (Art. 199.)

11. Square the pieces for the door to dimensions, and join the rails and stiles with a haunched mortise-and-tenon joint. (Fig. 409 and Art. 165.)

12. Cut the grooves for the panel as shown in Figure 408, where the rear of the panel comes flush with the rear of the members of the frame, or make a panel from ¼-in. plywood, and cut the grooves as explained in Article 176. Remember that the panel sets back ½ in. from the front of the door frame. (See also Fig. 421.)

13. Cut the five blocks, which are all ½ in. thick, and glue them to the face of the panel as shown. (Figs. 408 and 409.)

14. Make the molding either by hand (Art. 244), or by machine. Miter and glue the molding as shown in the drawing. (Art. 245.)

15. Hinge the door with loose-pin hinges (Fig. 246) or with invisible hinges. (Fig. 247.) See the rules for applying hinges. (Art. 200.) A lock (Art. 201), or a ball catch (Art. 205), may serve to fasten the door.

If double doors are made as shown in Figure 410, two flush bolts (Art. 204) should be used for fastening the left door.

16. Make the top, and fasten it in place according to directions given in Articles 139, 140, or 141, 189, and 199.

17. The split turning (Art. 231) is a suitable form of decoration which may be added.

18. Oak and walnut were the principal cabinet woods of the time. If the cabinet is made of the former, it should be given a coat of water stain (Arts. 262 and 266), followed by a coat of wood filler (Art. 267), a thin coat of shellac (Art. 268), and wax. (Art. 271.) See also Article 261 before beginning the finishing processes.

Fig. 410. Cabinet partly finished; double doors to be inlaid

335. **Bedside Table.** The table shown in Figures 411 and 412 is designed so that it may be used for one of three different purposes. The column and base, which are typical examples of American-Empire design, serve for all three types of tables. The top may be constructed as a bedside table, a chess table, or a sewing table.

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
1	Column	2¾	2¾	19¾
1	Base	1½	5	5
3	Legs	1½	2	7½
1	Board to Fit Top of Column	¾	3	12
3 Brass Claw Feet				

SUGGESTED ORDER OF TOOL OPERATIONS

336. The Base and Column. (1) Turn the column as explained in Articles 225 and 226. (See also Fig. 394.)

2. Cut out and shape the base and the three legs, using the spindle sander. (Art. 227.) (See detail, Figure 412.)

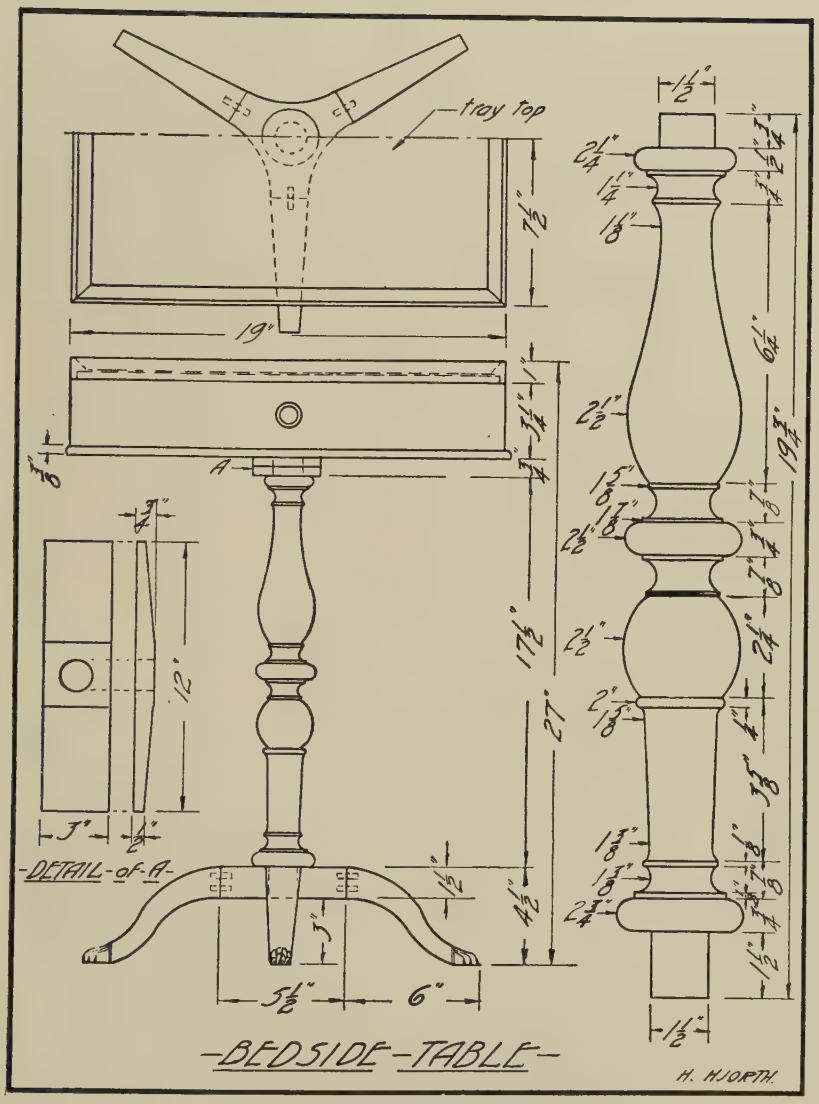


Fig. 411. Bedside table

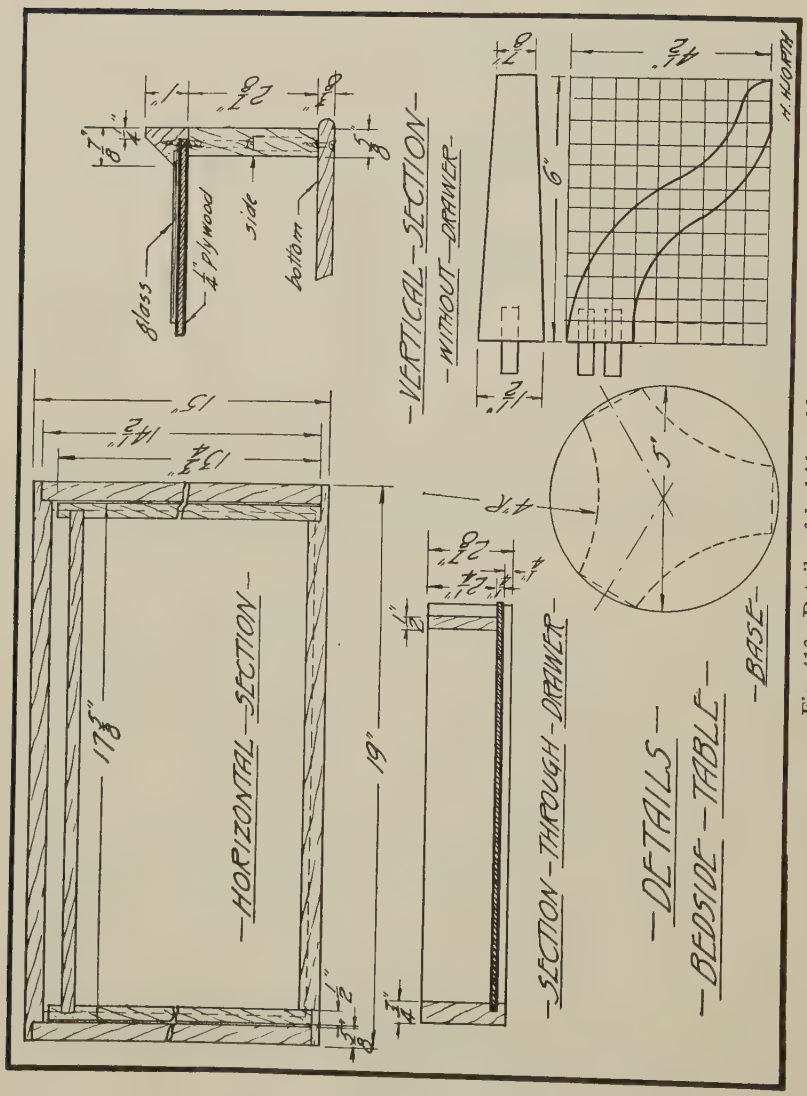


Fig. 412. Details of bedside table.

3. Join the legs to the base by a doweled butt joint (Art. 156), and glue them one by one as shown in Figure 242.

4. Claw feet of cast brass may be bought and fitted to the ends of the legs. This adds a great deal to the appearance of the piece.

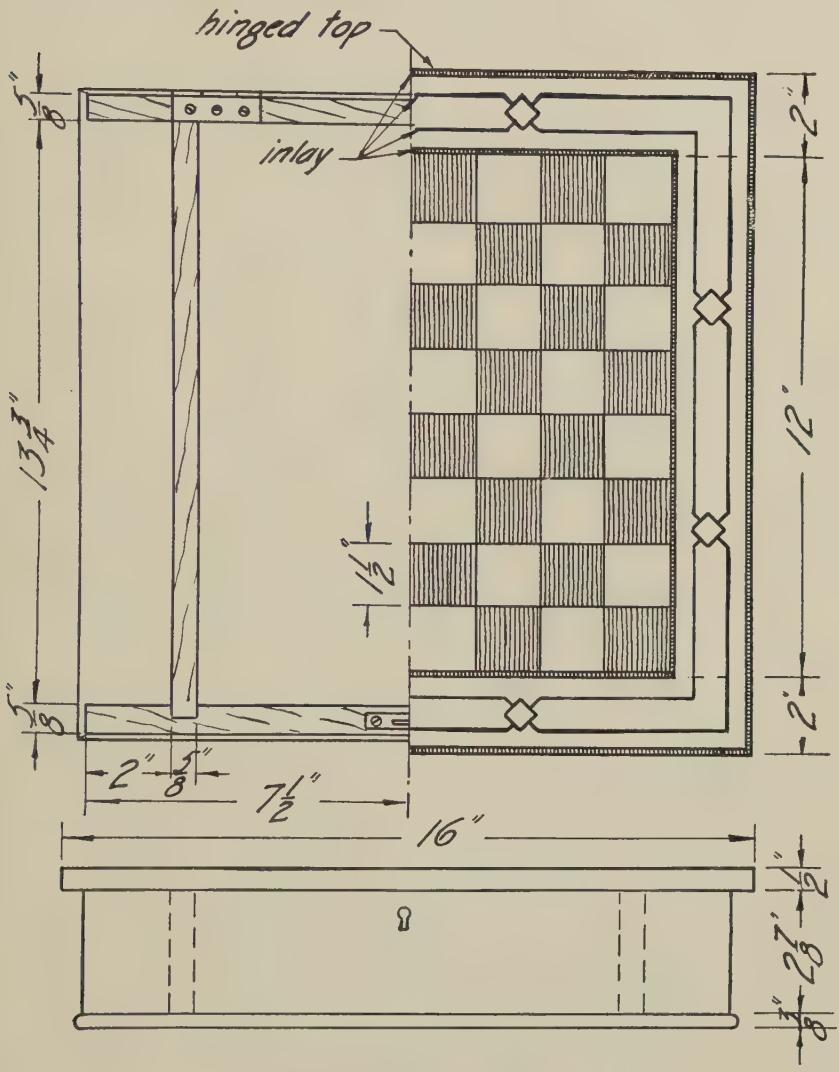


Fig. 413. Chessboard arrangement

5. Bore a 1½-in. hole in the center of the base for the column, and glue the two together. Making and gluing the board, shown in the detail of A, Figure 411, to the top of the column, completes the lower part of the table.

337. The Bedside Table Top. (1) Make the frame for the tray as shown in the vertical section of Figure 412, joining the corners with a doweled miter joint. (Art. 179.) Insert the glass in the groove cut for it, using a little putty to make it water-tight. Nail the bottom in place with fine brads.

FOR BEDSIDE TABLE

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
2	Sides	5/8	2 7/8	14 1/2
1	Back	5/8	2 7/8	19
1	Drawer Front	3/4	2 7/8	19
2	Drawer Sides	1/2	2 7/8	13 3/4
1	Drawer Back	1/2	2 1/4	17 1/8
1	Drawer Bottom	1/4	17 1/8	14
1	Bottom	3/8	19 3/8	15 3/8
2	Tray Frame	7/8	1	19
2	Tray Frame	7/8	1	15
1	Tray Bottom	1/4	14 1/2	18 1/2
1 Glass, 14 by 18 in.				
1 Drawer Knob				

FOR CHESS TABLE

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
2	Front and Back	5/8	2 7/8	15
2	Sides	5/8	2 7/8	14 3/8
1	Bottom	3/8	15 3/8	15 3/8
1	Top	1/2	16	16
1	Ebonized Wood	1/8	7	15
1	Light Wood	1/8	8 1/2	15
10 ft. Line Inlay 3/16 in. wide				
15 ft. Line Inlay, 1/16 in. wide				
2 Fast-Joint Butt Hinges				
1 Box Lock				
1 Thread Escutcheon				

FOR SEWING TABLE

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
2	Front and Back	5/8	2 7/8	19
2	Sides	5/8	2 7/8	14 3/8
1	Bottom	3/8	15 3/8	19 3/8
1	Top	1/2	16	20
2	Partitions	1/4	2 7/8	17 3/4
4	Partitions	1/4	2 7/8	4 1/4
2	Partitions	1/4	2 7/8	5 1/2
2 yd. Line Inlay, 1/8 in. wide				
1 Inset				
2 Fast-Joint Butt Hinges				
1 Box Lock				
1 Thread Escutcheon				

2. Square the sides and back to dimensions (Art. 138), and join them with a rabbet joint (Art. 146), or with a dado and rabbet joint. (Art. 151.)

3. Hold these pieces in place by nailing a cleat temporarily across the front edges of the sides. Glue and clamp the joints.

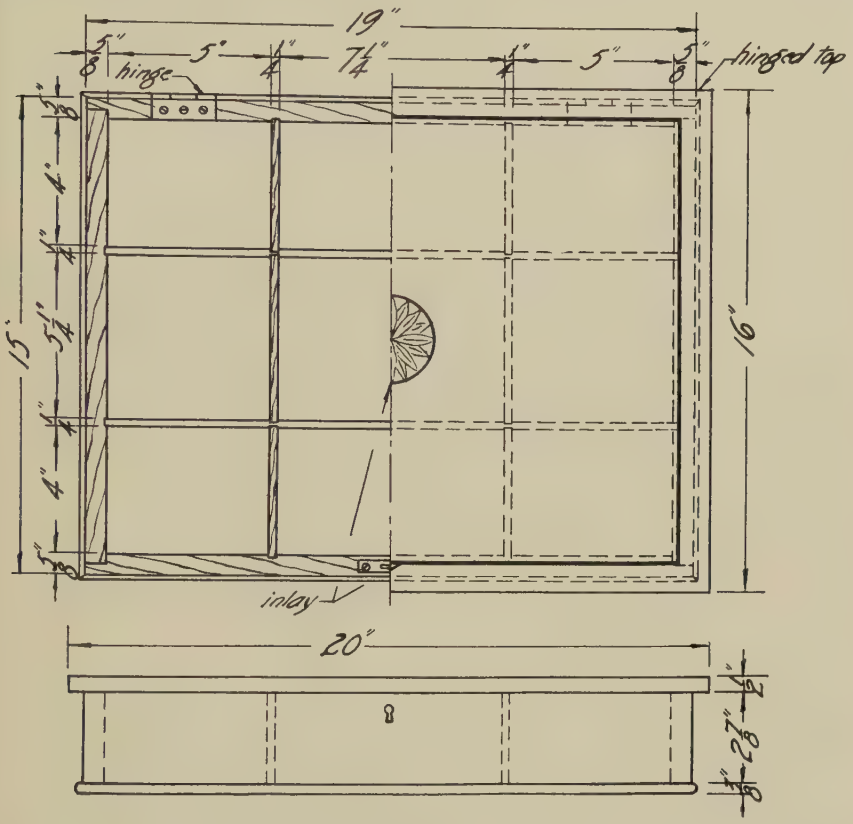


Fig. 414. Sewing-table arrangement

4. Plane the upper edges level and smooth, so that the bottom of the tray makes a perfect joint all around. Screw the tray to the top edges of the sides and back, as shown in the vertical section in Figure 412. Use very thin screws. Smooth the sides and back with a scraper and sandpaper.

5. Make the bottom, and screw it in place.

6. Construct the drawer according to the description given in Articles 174 and 193. Place the guides near the center as shown in Figure 220. (Art. 175.) Attach the drawer knob as explained in Article 210.

338. The Chess-Table Top. (1) Square the four pieces, forming the frame in Figure 413, to dimensions (Art. 138), join them with dado joints (Art. 147 or 152), and glue (Art. 190).

2. Make the bottom, and screw it in place in the same manner as shown in the detail of the bedside table.

3. Make the top for the chess table. It is advisable to glue it up of several narrow pieces in order to prevent warping. (Arts. 139, 140, 141, and 189.)

4. Make the checkerboard, and apply it to the top according to directions given in Article 185.

5. It is strongly recommended to veneer the underside of the top to prevent warping. (Arts. 249 and 309.)

6. Attach the hinges (Art. 200) and the lock (Art. 201).

339. The Sewing-Table Top. (1) Square the four pieces of the frame to dimensions (Art. 138), and make the rabbet joints (Art. 146), or better, dado and rabbet joints (Art. 151).

2. Make the partitions of ¼-in. plywood, and cut the dadoes. (Art. 147, or 152, or 153.)

3. Glue the frame together. (Art. 190.)

4. Make and screw the bottom to the frame as shown in the detail drawing of the bedside table.

5. Fit the partitions in place.

6. Make the top according to directions given in Articles 139, 140, 141, and 189.

Fig. 415. Chess table

7. The top may be inlaid as shown in Figure 413 (Arts. 234 and 235), or better still, veneered on both sides. (Arts. 248 and 249.)

8. When finished, the top is hinged to the frame. (Art. 199.) The

sewing table may be locked with a box lock as shown in Figure 254. (Art. 201.)

9. Prepare the surface for staining (Art. 261), and apply a coat of water stain. (Arts. 262 and 266.) If the wood has a close grain, omit the wood filler, and apply instead a coat of shellac. (Art. 268.) Rub

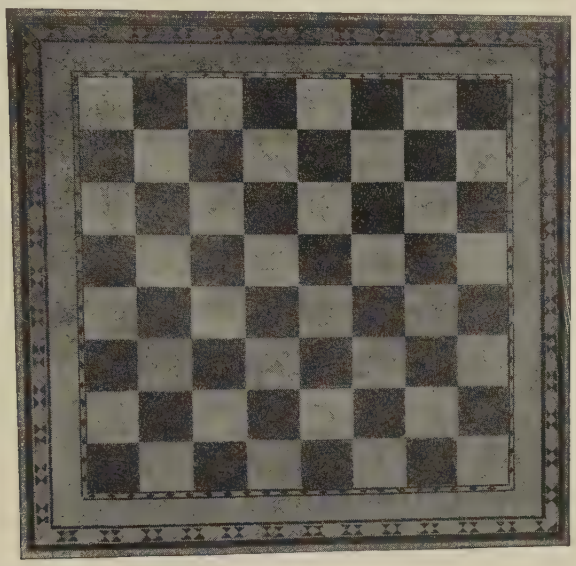


Fig. 416. Chess-table top

this down and follow with two coats of lacquer (Art. 269), or varnish. (Art. 270.)

340. Dining Chair. Perhaps no other article of furniture is made in so many different types and shapes as chairs. This is because chairs have so universal a use. They are needed in every room of the house.

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
2	Front Legs	1½	2	17¾
2	Rear Legs	1	3½	34
1	Front Rail	1¼	2½	15
1	Rear Rail	¾	2½	12½
2	Side Rails	¾	2½	13½
1	Back Rail	¾	3	12½
2	Back Rails	¾	¾	12½
1	Pierced Panel	½	2½	12½
2	Stretchers	½	1	14¾
4	Corner Blocks	1	2	3½
2	Seat-Frame Rails	¾	2	14½
1	Seat-Frame Rail	¾	2	12½
1	Seat-Frame Rail	¾	2	17

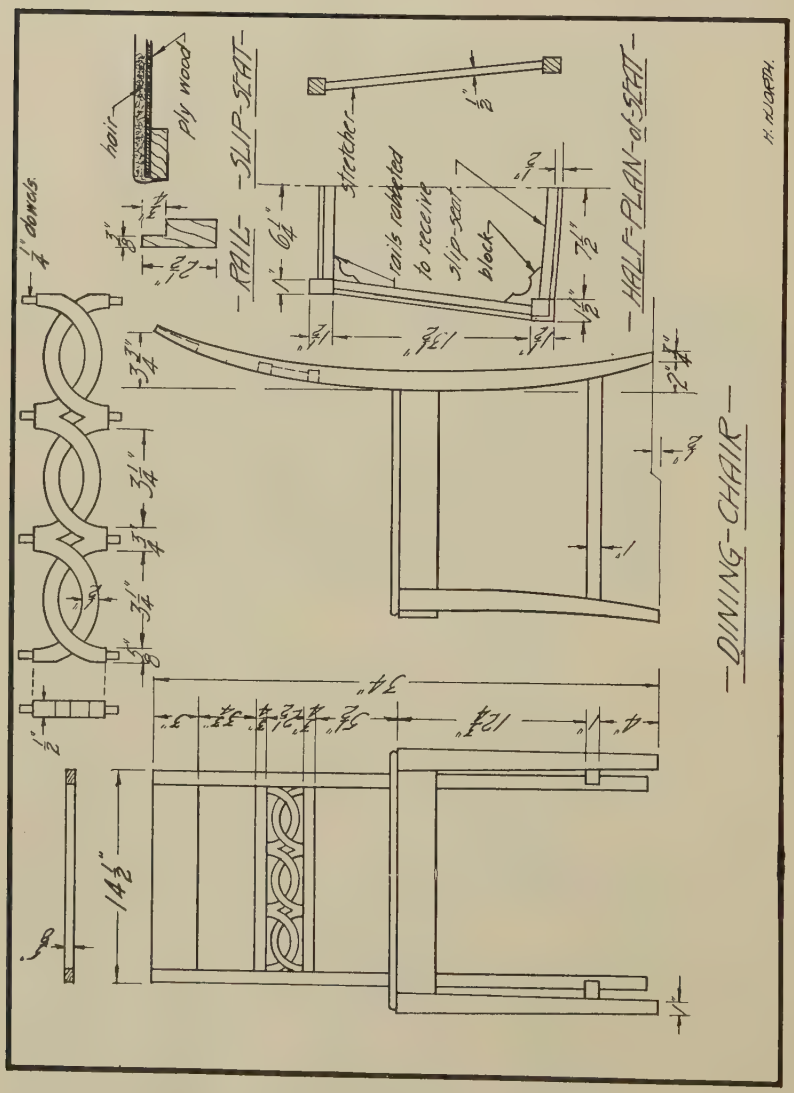


Fig. 417. Dining chair

Therefore, we have easy-chairs, dressing chairs, kitchen chairs, dining chairs, and numerous other types. From the point of view of the non-professional a dining-room chair (Fig. 417) is one of the easiest types to make.

SUGGESTED ORDER OF TOOL OPERATIONS

1. Make templates for the legs; cut and smooth them according to dimensions.
2. Cut all the rails for the back, and saw the pierced panel with a

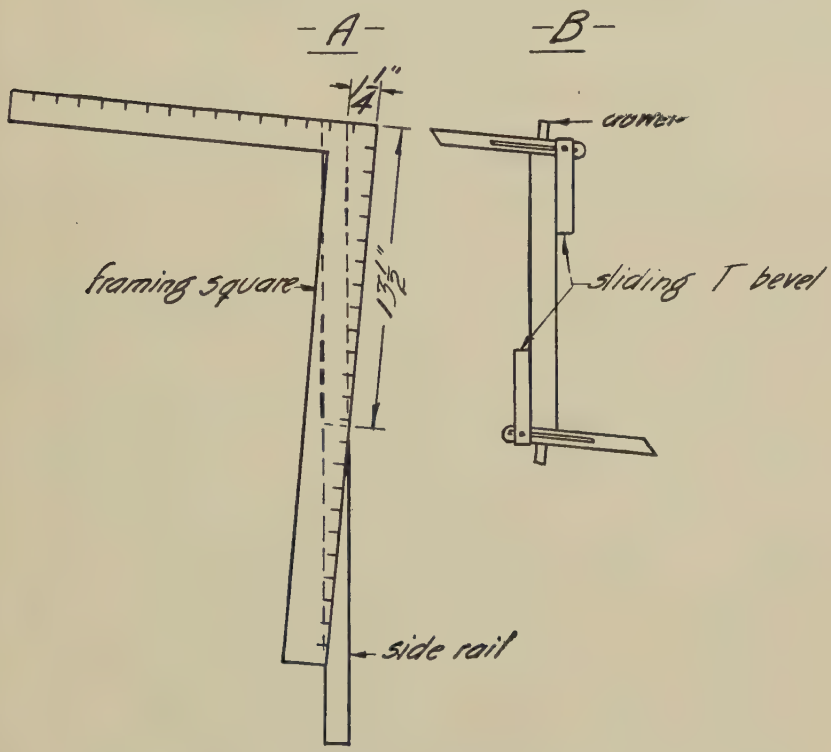


Fig. 418. Marking angles on side rails

coping saw. It is advisable to use plywood for this panel. It may be carved slightly as suggested on the strapwork panel, Figure 319.

3. Cut the rabbet on the rear rail (Art. 146 or 153), and join this rail and the back rails and panel to the rear legs. Use doweled butt joints. (Art. 156.)
4. Glue up the back of the chair. (Art. 194.)
5. Square the front and side rails and the stretchers to dimensions. (Art. 138.)

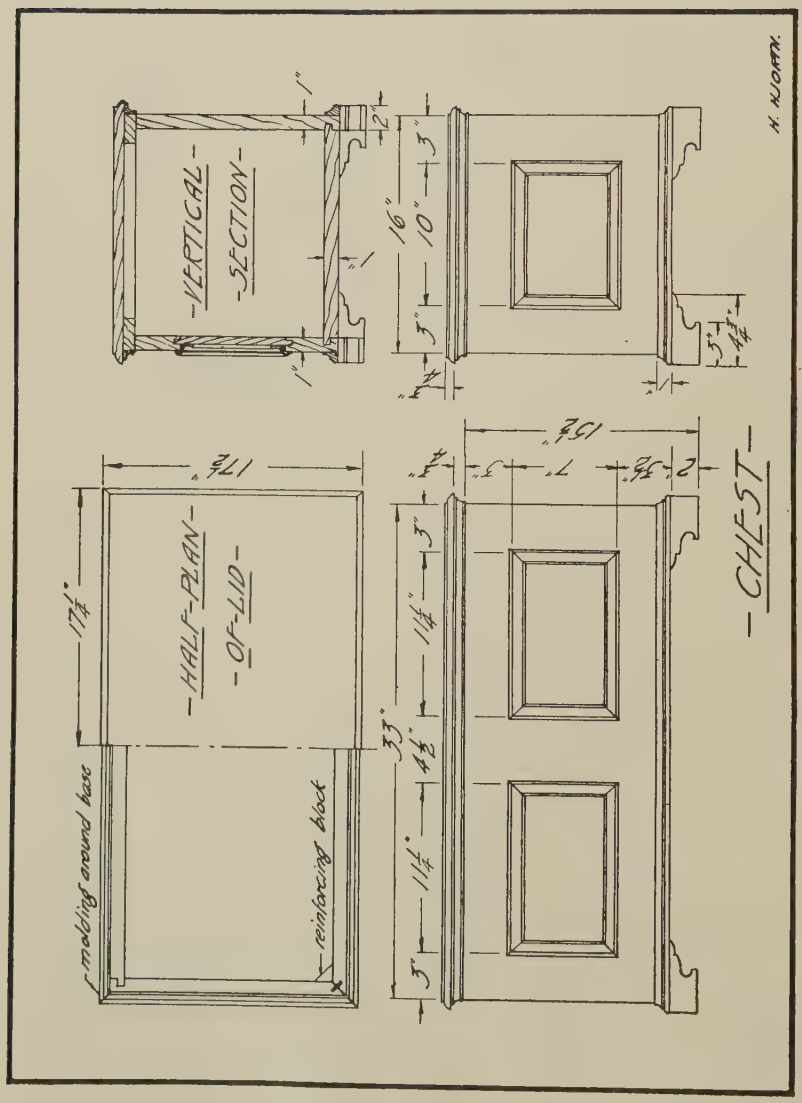


Fig. 419. Chest

6. Cut the rabbets in the front and side rails and also in the front legs.

7. As the back is narrower than the front of the chair, the ends of the side rails and stretchers are cut at an angle which is obtained as

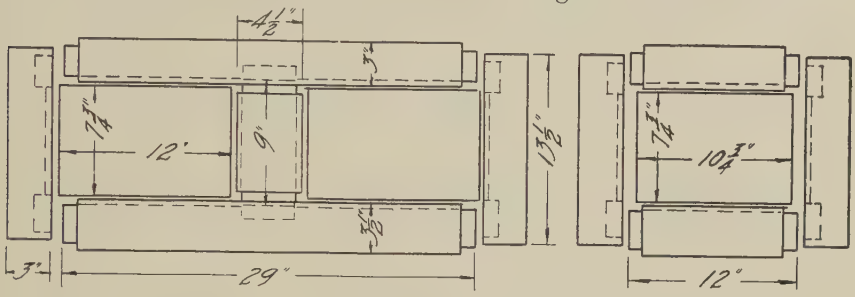


Fig. 420. Front and side assemblies of chest

follows: Find the length of the side rail, or 13½ in., in the drawing, and find half the difference between the length of the front rail and the rear rail, or $\frac{15 \text{ in.} - 12\frac{1}{2} \text{ in.}}{2} = 1\frac{1}{4}$ in. Take these two numbers on the blade and tongue of a steel square (Art. 7), lay it on the edge of the rail as shown at A, Figure 418, and mark the angle along the tongue. Set a sliding T bevel (Art. 6) to this angle, and mark at the other end of the rail B, Figure 418. Lay out the stretchers accordingly.

8. Bore for the dowels at right angles to the angle of the cut. (Art. 156.)

BILL OF MATERIAL

No. of Pieces	Description	Thickness in Inches	Width in Inches	Length in Inches
1	Front Assembly	1	3	29
1	Front Assembly	1	3½	29
2	Front Assembly	1	3	13½
1	Front Assembly	1	4½	9
2 Panels	Front Assembly	½	7¾	12
2	Side Assembly	1	3	12
2	Side Assembly	1	3½	12
4	Side Assembly	1	3	13½
2 Panels	Side Assembly	½	7¾	10¾
1	Back	1	13½	32
1	Bottom	1	15	32
1	Lid	¾	17½	34½
2	Lid Frame	¾	2	33
2	Lid Frame	¾	2	16
2	Lid Frame	¾	2	14
8	Feet	2	2	4¾
1	Base Molding	¾	1	60
1	Top Molding	½	¾	60
1	Panel Molding	½	¾	10 ft. 0 in.
1 Chest Lock				
2 Chest Hinges				
1 Escutcheon				

9. Glue the front legs and rails first. Then glue the side rails and stretchers to the front and back of the chair. (Art. 194.)

10. Reenforce the corners by gluing and screwing blocks to rails. See the half plan of the seat in Figure 417.

11. Make the frame for the seat, joining the pieces with slip joints. (Art. 167.)

12. Upholster the seat according to directions given in Article 256. If a pad seat or a caned seat is desired, see Articles 254, 258, or 259.

13. A chair made of hard, close-grain wood, should be given a coat of water stain (Art. 262), a coat of shellac (Art. 268), and two coats of lacquer (Art. 269) or varnish. (Art. 270.) This may be followed by a coat of liquid wax. (Art. 271.)

14. Chair tips (Art. 209) may be attached to the legs of the chair.

341. Chest. A chest is a type of furniture that has been used by man for hundreds of years. It is a very desirable piece of furniture and may be used for many different purposes. Cedar chests or cedar-lined chests are used chiefly for the storing of clothing. (Fig. 423.)

SUGGESTED ORDER OF TOOL OPERATIONS

1. Make the front assembly and the side assembly (Fig. 420) according to directions given in Articles 176 and 190. See the detail drawing, Figure 421, showing two types of panels.

2. Make the bottom and the back as explained in Articles 139, 140, or 141 and 189.

3. Make the spline miter joints at the two front corners of the chest. (Art. 181.)

4. Clamp together temporarily, as shown in Figure 239, and fit the bottom and the back in place. (Art. 150 and 151.)

5. Glue the chest as shown in Figure 239.

6. Make the blocks for the feet. Saw the curves on a band saw, and smooth on a spindle sander. (Art. 227.)

7. Miter these blocks in the corners, and dowel them together. (Art. 156.) Glue each pair by wedging as explained in Article 195.

8. Screw the feet to the underside of the bottom, letting them project ¾ in. beyond the sides of the chest.

9. Make the top as explained in Articles 139, 140, or 141 and 189. Shape its edges as shown in the drawing, Figure 419. (Art. 247.)

10. Make the frame for the underside of the lid as shown in the detail, Figure

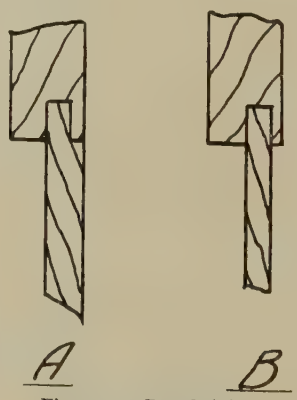


Fig. 421. Panel joints

422. Use slip joints in the corners. (Art. 167.) Screw this frame to the underside of the lid. (Art. 198.)

11. Make the top and base moldings (Art. 244), miter them in the

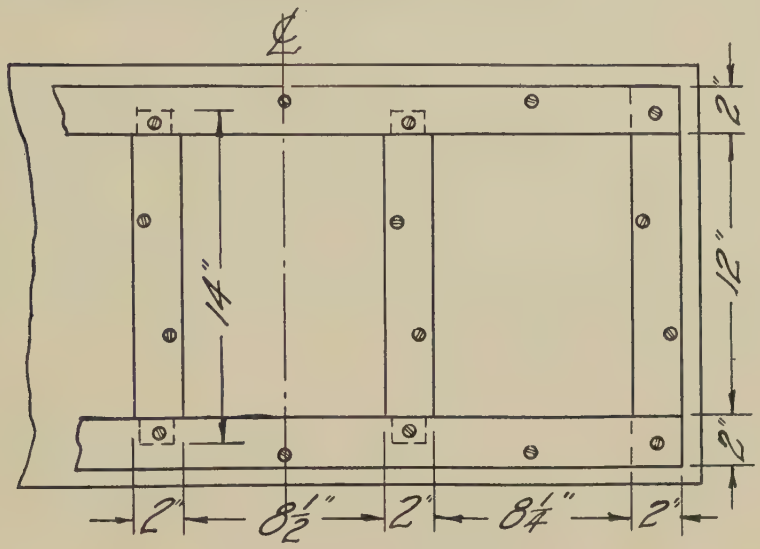


Fig. 422. Underside of lid

corners, and glue them in place by driving in fine brads. (Art. 245.)

12. Apply the molding to the panels according to the design desired. (Fig. 321.) On the chest shown in Figure 423, square blocks were glued

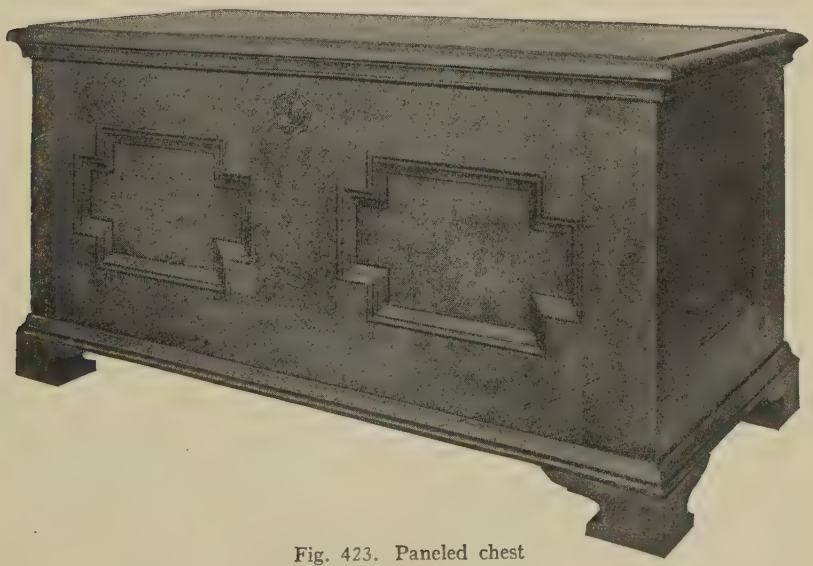


Fig. 423. Paneled chest

to the corners and planed level and smooth with the rails and stiles. The molding was then cut and fitted around these blocks.

13. The lid is hinged to the chest with a special heavy type of hinge, called a "chest hinge." (Fig. 248.) A chest lock, Figure 254, is mortised into the front rail. Casters or glides may be applied to the feet of the chest. (Arts. 207 and 208.)

One or more trays might conveniently be fitted to the inside of the chest. This chest, which is rather small in size, may easily be made larger without destroying the proportions of the design. If it is made longer, a third panel may be added to the front assembly. If clothes are to be kept in the chest, it may be lined with thin cedar boards.

14. The chest shown in Figure 423, was made of maple. It was given a coat of amber-colored water stain (Art. 262), a coat of white shellac (Art. 268), two coats of clear lacquer (Art. 269), and a coat of liquid wax. (Art. 271.)

INDEX

Acid stains or stains due to chemical action, 214
Air seasoning lumber, 235
Allowance for planing, 240
Angle mirror, 192
Annual rings in wood, 225
Applied projects, 250
Auger bit, 18; to sharpen, 60
Auger-bit gauge, 20
Automatic drill, 21
Automatic knife grinder, 51

Backsaw, 10
Ball catch, 137
Band saw, 36; brazing, 66; filing, 68; setting and sharpening, 67
Band-saw setting machine, 67
Bark on a tree, 226
Beads, carving, 181
Bed of a lathe, 140
Bedside table, 288
Belt sander, 49
Bench jointer, 39
Bit, auger, car, and dowel, 18; expansion, forstner, and gimlet, 19; ship auger, 18; twist, 19
Bit-brace extension, 20
Blind mortise-and-tenon joint, making a, 94
Block plane, 13
Blue prints and drawings, making, 250
Boards, matched, grooved, and beaded, 241
Board measure, 4, 240
Bookrack, drawing of a, 251
Bookshelves, gluing, 122
Borders, carving, 182
Boring bit, machine, 46
Boring tools, 18
Brace, plain, ratchet, 20
Brace measure, 4
Bradawl, 19
Brass socket, 138
Brazing band saws, 66
Bullnose plane, 13
Butt chisel, 16
Butt gauge, 8
Butt hinge with loose pin, 132
Cabinet, 286; gluing a, 124
Cabinet scraper, 15; to sharpen, 59
Cabinet woods, 246, 248
Calipers, inside and outside, 8
Cambium in a tree, 226
Cane seat, weaving a, 207
Cane webbing, applying, 209
Car bit, 18
Carving, beads, 181; borders, 182; chamfers and hollows, 182; a double spiral on a turned cylinder, 178; a single spiral on a turned cylinder, 177
Carving, simple, 181
Carving tools, 17, 181
Casters, glides, and chair tips, attaching, 137
Catches and bolts, fastening, 136
Cell formation in wood, 225
Chair, dining, 294; gluing a, 125
Chair tip, 138
Chamfers and hollows, carving, 182
Checkerboard, making a, 116
Cheek cuts, making, on a circular saw, 101; sawing, 95
Chess-table top, 293
Chest, 299
Chest hinge, 132
Chest lock, 135
Chisel, butt, firmer, framing, mortise, and paring, 16; right or left skew, and round-nose, 62
Chucks, 142
Chuck turning, 162
Circular plane, 13
Circular saw, 30; directions for using, 35; filing, 64; jointing, 63; gumming and setting, 65; sharpening, 63; side filing, 66
Clamps, C, column, and steel bar, 23
Clamping and gluing, 119
Claw hammer, 21
Combination machine, 28
Compass saw, 11
Concave cuts, making, 154
Convex cuts, making, 155
Coping moldings, 187
Coping saw, 11
Countershaft, 141

Countersink, 19
Crosscut saw, 10; filing a, 55
Cross-lap joint, making a, 91
Cutting long pieces and short pieces to length, 33

Dado head, 34
Dado joint, making a, 79
Dado plane, 14
Dado-and-rabbet joint, making a, 82
Decalcomania transfers, applying, 193
Decorating by overlays, frets, or veining, 192
Decoration of furniture, 166
Diamond-point or spear-point chisel, sharpening, 62
Dining chair, 294
Disk, turning a, 157
Disk sander, 50
Dividers, 8
Door bolt, 136
Double-acting hinge, 132
Double-spindle shaper, 46
Dovetail joints, 103
Doweled joints and segments, gluing, 127
Dovetail saw, 10
Dovetail-lap joint, making a, 91
Dowel bit, 18
Dowel joints, 85
Doweled butt joint, making a, 85
Doweled segments, 88
Doweling jig, 89
Drawer, gluing a, 124; making a, 107
Drawer rails and guides, making, 108
Drawings and blue prints, making, 250
Drawknife, 17
Drill, automatic, hand, and reciprocating, 21
Drum sander, 50
Drying defects in lumber, 238

Early English gate-leg table, drawing of, 258
Edges of table tops, shaping, 188
Elbow catch, 136
End table, 276
End-lap joint, making an, 90
End-lap joint with rabbet, making an, 91
Escutcheons, 136
Expansive bit, 19

Faceplates, 142
Fast-joint butt hinge, 132
Fiber seat, weaving a, 204
Files and rasps, 22
Filing, band saws, 68; circular saws, 64; a crosscut saw, 55; a ripsaw, 55
Finger joint, making a, 114
Finishing coats, 216; advantages and disadvantages of, 219; application of, 221
Firmer chisel, 16
Flush bolt, 137
Folding rule, 2
Footstool, drawing of a, 255
Fore plane, 13
Forstner bit, 19
Frame or panel, gluing a, 122
Framing chisel, 16
Furniture and interior woodwork, painting, 220
Furniture pulls and knobs, attaching, 138

Gain joint, making a, 81
Gain on door, chiseling, 134
Gauge, auger-bit, 20; butt, 8; marking, 7; mortising, 8; panel, 7; plane, 15; segment, 33; slitting, 7
Gimlet bit, 19
Glide, 138
Glue, preparation of, 119
Gluing, bookshelves, 122; a cabinet, 124; a chair, 125; and clamping, 119; doweled joints and segments, 127; a drawer, 124; a frame or panel, 122; general directions for, 119; miters or irregular shapes, 126; two or more boards edge to edge, 120; veneers, 191
Gouges, 17; to sharpen, 57
Graduation of wood-trimmer table, 48
Grinding device, 56
Groove-and-rabbet joint, making a, 82
Grooved joints, 79; made with machine tools, 83; making, 81
Grooves, dadoes, and rabbets cut with a circular saw, 83; cut with a dado head, 83
Grooving head, 35
Gumming circular saws, 65

Hack saw, 11
Half-lap, multiple, dovetail joint, making a, 105
Hammer, claw, 21
Hand drill, 21
Hand planer or jointer, 39
Hand screw, 24
Hand tools, 1

Hardware, application of, 130
Hatchet, 22
Haunched mortise-and-tenon joint, making a, 97
Headstock, **141**
Heartwood, 225
Hinge, butt with loose pin, chest, double-acting, fast-joint butt, and invisible, 132
Hinges, fastening, 131
Holes and other imperfections in surface, filling, 221
Hollow-chisel mortiser, 44

Inlaying, 167; insets, 171; lines or bands, 169
Interior woodwork and furniture, painting, 220
Invisible hinge, 132

Jack plane, 12
Jig saw, 38
Jointer, 13
Jointer or hand planer, 39
Jointing, boards for gluing, 71; circular saws, 63; a saw, 54
Joints, grooved, 79

Keyhole saw, 11
Kiln seasoning lumber, 235
Kilns, types of, 237
Knife grinder, automatic, 51
Knife-grinding attachment, 40

Lacquer, applying, 216
Lamp standard, 272
Lap or halving joints, 90
Lathe, speed of a, 142
Lathe and its parts, 140
Legs for tables and cabinets, squaring, 75
Legs joined to a turned column with dowels, 87
Lines or bands, inlaying, 169
Linseed oil, applying, 219
Locks, attaching, 134
Locks, chest, mortise, and rim, 135
Logging operations, 230
Logs, sawing, 231
Lumber, air seasoning, 235; for building purposes, 247; for cabinetwork and interior woodwork, 246; conservation of, 224; drying defects in, 238; kiln seasoning, 235; manufactured, 239; selection and uses of, 246; standard lengths and thicknesses of, 239

Machine boring bit, 46
Machine tools, 27
Making and squaring a table top, 74
Mallet, 22
Manufactured boards, 243
Manufactured lumber, types of, 241
Marking gauge, 7
Match plane, 14
Matching and applying veneers, 189
Measure, board, brace, and octagon, 4
Measuring tape, 2
Measuring tools, 2
Medullary rays in wood, 226
Mirror, angle, 192
Mirror frame, 265
Miter, doweled, nailed, slip-feather, and spline, 111
Miter and try-square, 3
Miter box, 11
Miter joint, making a, 110
Miters or irregular shapes, gluing, 126
Mitering and applying moldings, 186
Moisture content of wood, 236
Moldings, 241; coping, 187; making, 185; mitering and applying, 186
Molding plane, 14
Monkey wrench, 24
Mortise, making a, on a mortising machine, 98
Mortise-and-tenon joints, 94
Mortise chisel, 16
Mortise lock, 135
Mortising gauge, 8
Mortising head, 45
Mortising machine, 44

Nail set, 21

Occasional table, 280
Octagon measure, 4
Oil stains, 214
Overlays, frets, or veining used for decoration, 192

Pad seat with a roll edge, making a, 197
Painting furniture and interior woodwork, 220
Panels decorated with moldings, 185
Panel gauge, 7
Panel structure, making a, 109
Paring chisel, 16
Parting or cut-off tool, sharpening, 61

Patternmaker's spokeshave, 15
Plain brace, 20
Plain pad seat, making a, 196
Plain- and quarter-sawing, 232
Plane, block, bullnose, and circular, 13; dado, 14; fore, 13; jack, 12; jointer, 13; match, molding, rabbet-and-fillister, and router, 14; smooth, 13; universal, 14
Plane gauge, 15
Plane iron, to sharpen a, 55
Plane parts, 12
Plane or surfacer, 41
Planer or trimmer knives, sharpening, 68
Planing and squaring to dimensions, 70
Plants, man's dependence on, 224
Pliers, gas, side-cutting, 24
Plug and washer cutters, 20
Plumb and level, 9
Plumb bob, 9
Plywood, 243
Porous woods, 227
Portable sander, 50
Priming coat, application of, 220
Projects, applied, 250
Pusher for jointer, 41

Rabbet-and-fillister plane, 14
Rabbet joint, making a, 79
Rafter table, 5
Rasp or file, cleaning, 62
Rasps and files, 22
Ratchet brace, 20
Reciprocating drill, 21
Reeds, spiral, cutting, 176; straight, cutting, 174
Right or left skew chisel, sharpening, 62
Rim lock, 135
Ripsaw, 9; filing a, 55
Rotary veneer cutter, 242
Round-nose chisel, sharpening a, 62
Router, portable, 47
Router plane, 14
Rule, folding, 2
Rule joint, making a, 112

Sander, belt, 49; disk, drum, portable, and spindle-and-disk, 50
Sanding in a lathe on a disk, 161; on a spindle, 156
Sanding pad, pneumatic, 49
Sapwood, 225
Saw, back, 10; band, 36; circular, 30; compass and coping, 11; crosscut and dovetail, 10; hack, 11; jig, 39; keyhole, 11; rip, 9; swing cut-off, 28; turning, 11; under-swing cut-off, 30
Saw, jointing a, and setting a, 54
Saw bench, variety, 36
Saw set, 55
Screws, applying, 130
Screw driver, automatic, plain, 21
Sectional feed roll for planer, 43
Segment gauge, 33
Serving tray, 263
Setting, band saws, 67; circular saws, 65; a saw, 54
Sewing-table top, 294
Shaper, double-spindle, 46; portable, 47
Shaping edges of table tops, 188
Sharpening of, auger bit, 60; band saws, 67; cabinet scraper, 59; circular saws, 63; diamond-point or spear-point chisel, 62; gouges, 57; parting or cut-off tool, 61; planer or trimmer knives, 68; rasp or file, 62; right or left skew chisel and round-nose chisel, 62; skew chisel and square-nose chisel, 61; tools, 54
Shellac, applying, 216
Ship auger, 18
Shoulder cut, sawing, 96; making, on a circular saw, 101; making, 152
Shrinkage of wood, 237
Side filing circular saws, 66
Simple carving, 181
Skew chisel, sharpening, 61
Slide supports, making, 115
Slip joint, making a, 98
Slip seat, upholstering a, 200
Slitting gauge, 7
Smooth plane, 13
Spindle-and-disk sander, 50
Spiral, double, carving on a turned cylinder, 178; single, carving on a turned cylinder, 177
Spiral reeds, cutting, 176
Spirit stains, 214
Split turning, 164
Spokeshave, 15
Staining, general directions for, 214
Stains, acid, oil, and spirit, 214; water, 213
Stand with round tilting top and with octagonal tilting top, 269
Standard lengths and thicknesses of lumber, 239

Steel square, 3
Stock, centering and clamping, in a lathe, 144
Stool, 278
Straight reeds, cutting, 174
Strapwork, 184
Square legs for tables and cabinets, tapering, 76; on the circular saw, 77
Square-nose chisel, sharpening, 61
Squaring, legs for tables and cabinets, 75; small boards to dimension, 70; a table top, 73
Surface, preparation for painting, 220
Surface decoration, 166
Swing cut-off saws, 28

T bevel, sliding, 3
Table catch, 137
Table top, fastening in place, 131; making and squaring, 74; shaping edges of, 188
Tailstock, 142
Taper cuts, making, 153
Tapered spirals, laying out, 180
Tapering square legs for tables and cabinets, 76
Teeth, of crosscut saw, 10; of ripsaw, 9
Tenons, cutting, on a circular saw, 99
Testing for wind, 76
Through mortise-and-tenon joint, making a, 97
Through, multiple, dovetail joint, making a, 103
Tinner's snips, 24
Tongues, grooves, and rabbets cut on a shaper, 83
Tools, boring, 18; carving, 17; hand, 1; machine, 27; measuring, 2; sharpening of, 54
Toolrest, 142
Trammel points, 8
Trees, botanical division of, and life function of, 223; reproduction of, 229
Try-square, 2
Turning, a disk, 157; a plain cylinder 147
Turning saw, 11
Turning tools, sharpening, 60
Twist bit, 19

Umbrella stand, 284
Undercoats, application of, 221
Under-swing cut-off saw, 30
Universal plane, 14
Upholstering a slip seat, 200
Upholstery, 196

Variety saw bench, 36
Varnish, applying, 217
Veined panel, 193
Veneers, 242; gluing, 191; matching and applying, 189
Veneer cutter, rotary, 242
Vise, quick-acting, 2

Water stains, 213
Wax, applying, 218
Weaving, a cane seat, 207; a fiber seat, 204
Wood, 223; cabinet, 246, 248; moisture content of, 236; porous, 227; seasoning of, 233; shrinkage of, 237; structure of, 224; weight of, 229
Wood filler, applying, 215
Wood finishing, 212
Wood surface, preparing a, 212
Wood trimmer, 48
Wood-trimmer table, graduation of, 48
Wood turning, 140
Woods used in building construction, 248
Workbench, 1
Working drawings, reading, 250

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